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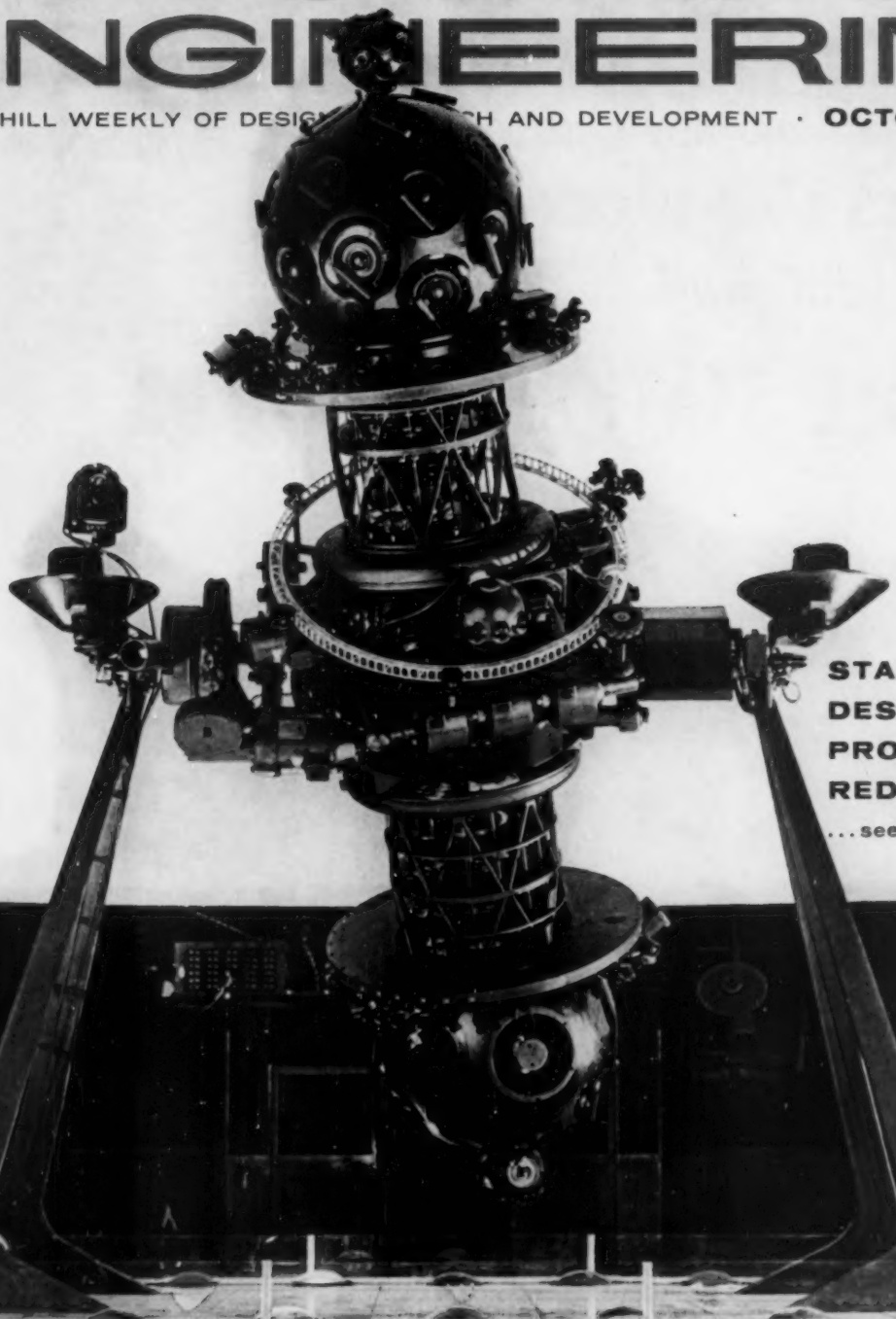
McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT · OCTOBER 17, 1960



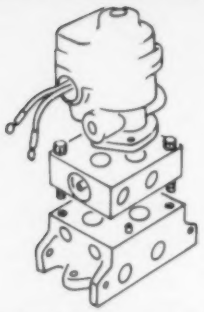
STAR DESIGN PROJECTOR REDESIGNED

...see page 3

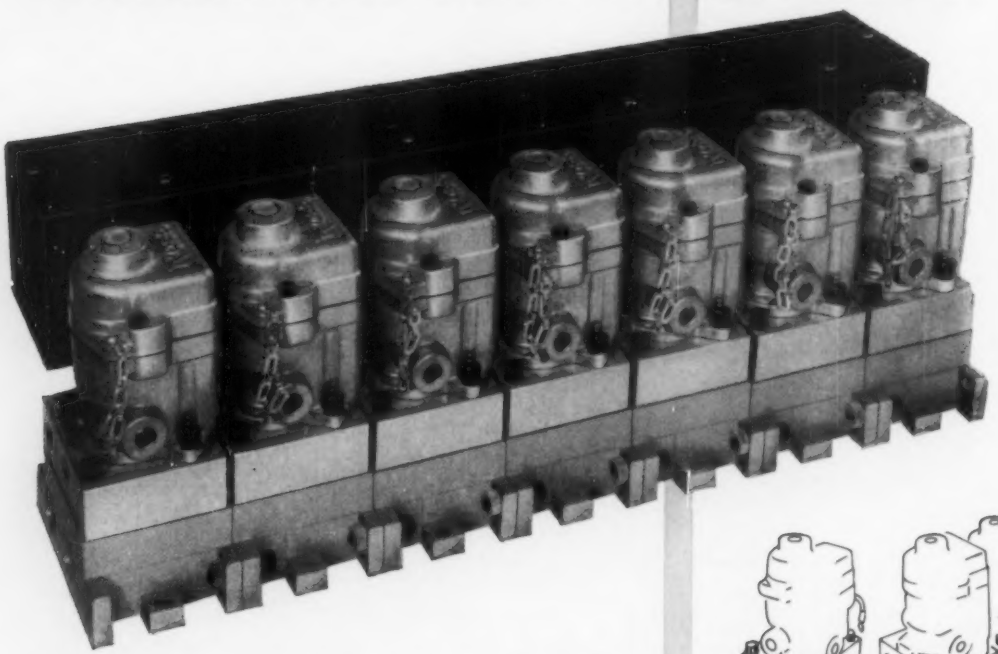
WHEN HELICAL GEARS GET YOU OUT OF TIGHT SPOTS . . . page 61
CREATIVITY TESTS ARE HELPFUL . . . page 73
HOW RESISTANCE TRANSDUCERS COMPARE . . . page 76

Now manifold any number of ROSS 4-way PACER valves with new

SINGLE STATION MANIFOLDS



Attach PACER 4-way valve to manifold box with just two cap screws. All air connections are automatically made.



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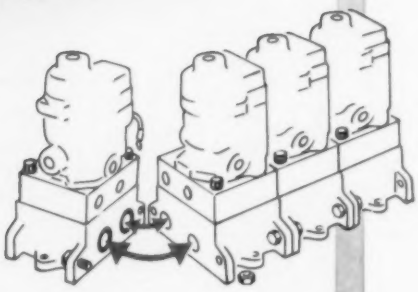

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McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

October 17, 1960 Vol. 31, No. 43

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INTERESTING TO NOTE

On our cover—the new projector built for New York's Hayden Planetarium by Carl Zeiss. Design details on page 70.

Some textbooks still claim that Columbus set sail from Palos, Spain in 1492 to prove that the earth was round. Actually, learned men since about the 6th century BC had known the earth is round. (It was at that time that Anaximander built the first celestial globe.) Ptolemy later proposed the theory that the earth was not only a sphere but also the center of the universe. Then, several years after Columbus discovered America, Copernicus suggested the heliocentric theory which superseded Ptolemy's concept. However, in both Ptolemy's and Copernicus' day, astronomers used celestial globes to help them understand the heavens. These wooden globes were predecessors of the modern planetarium.

Until the 20th century, the only time to observe the skies was in the evenings. In 1919 Prof Walter Bauersfeld, director of the Carl Zeiss firm, got the idea of a building containing projectors that could be moved and guided to display illuminated images of the heavenly bodies on a domed ceiling. It took Bauersfeld five years to build a working model of his planetarium. Then, in 1923, the heavens were artificially projected on a domed roof of the Zeiss works. The planetarium was an immediate success. Although there have been many improvements since the one first built by Bauersfeld, the original is still operating in Munich.

The Duke's Thermometer

Not too long ago, the temperature of molten steel—3000 F—was considered hot. Now we're confronted with the problem of measuring temperatures as high as 2 billion deg K—the temperature of some of the hottest stars.

The first man to develop a fairly accurate thermometer was the Grand Duke of Tuscany, Ferdinand II. In 1654, he placed a liquid in a sealed tube and noticed its rise and fall with temperature changes. About half a century earlier, Galileo inverted a tube of heated air into a bowl of water. As the air cooled it drew the water up the tube. The daily fluctuation of the water in the tube was thought, by Galileo, to be caused by changes in temperature. Actually Galileo had built a crude barometer without realizing it. Many years later a protege of Galileo, Torricelli, accurately interpreted the phenomenon and intentionally designed an instrument for measuring atmospheric pressure.

continued, next page

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A McGRAW-HILL PUBLICATION

October 17, 1960
Vol. 31, No. 43

Executive, Editorial, Circulation and Advertising Offices:
330 West 42nd St., New York 36, N. Y.
Telephone: LOngacre 4-3000
Teletype: TWX NY 1-1636
Cable Address: MCGRAW-HILL, NY

PRODUCT ENGINEERING is published weekly by McGraw-Hill Publishing Company, Inc. James H. McGraw (1860-1948), founder. US subscription rates for individuals in the field of the publication, $3 per year, single copies 50 cents; Canadian subscriptions $5 per year; foreign $25 per year, payable in advance. Printed in Albany, NY; second-class postage paid at Albany, NY. Title ® registered at US Patent Office. © Copyright 1960 by McGraw-Hill Publishing Company, Inc. All rights reserved, including the right to reproduce the contents of this publication, either in whole or in part.

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INTERESTING TO NOTE continued

Duke Ferdinand's thermometer went unnoticed for many years; then, in 1701, Isaac Newton suggested that the Duke's instrument be submerged in melting ice and the liquid level marked 0, while the level attained at body temperature be marked 12 and the interval divided into 12 equal parts. Gabriel Fahrenheit later found these divisions too large and adopted a much smaller unit for his temperature scale. Still the readings Fahrenheit achieved varied slightly. He experimented with substances other than water, finally deciding upon mercury because it stayed liquid well below the freezing point of alcohol. Furthermore, mercury expanded more uniformly with temperature than did either water or alcohol. Very few instruments, as old as Fahrenheit's thermometer, have changed so little in over three hundred years. Temperatures will always be troublesome, especially in high-temp systems, described on page 68.

Creativity in a Free Society

In the competition between the United States and the USSR it has been suggested that freedom of thought and the opportunity for the creative mind to be harnessed will tilt the balance in our favor. Only time will answer this question: It goes without saying, however, that creativity (see p 73) is one of the most fundamental assets necessary for the technological growth of any nation. When the active mind is stifled, progress must come to a halt. In his new book, *The Rise and Fall of the Third Reich*, William L. Shier describes how the poor education of scientists and engineers under Hitler did much to win the war for the Allies.

Hitler held professors in contempt and, in 1937, required all teachers to join the National Socialist Teachers' League, which taught all subjects according to the Nazi doctrine. The teaching of natural science, which had been Germany's forte for centuries, deteriorated rapidly in favor of racial science. Teachers like Einstein, Franck and Haber had to get out. When the director of the Institute of Physics at Dresden said, "Modern physics is an instrument of Jewry for the destruction of Nordic science," Germany's technological future was in trouble.

Sciences were taught according to the doctrine of Aryan superiority, and all became a subject of propaganda. For example, the journal *Deutsche Mathematik* proclaimed, "Any idea that mathematics could be judged nonracially carried within itself the germs of destruction of German science."

It is not surprising that the State's attempt to control the young scientist's mind had a drastic effect on college enrollments. After six years of Nazification, the number of university students dropped by more than half. The decline in engineering schools was even greater—from 20,474 to 9554. Even before the war, Germany's great chemical industry complained that it was rapidly losing its world leadership. It was one of the ironies of war that Nazi Himmler's successful attempt to hamstring Germany's atomic energy program, plus the defection of Europe's best creative minds, allowed the United States to jump in and become first to develop the atomic bomb.

—Benedict A. Leerburger Jr

NEXT WEEK IN PRODUCT ENGINEERING

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Some of the new designs are specifically for ac; they're smaller, quieter and longer lasting.

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DEVELOPMENTS TO WATCH...

Gear and bearing lubes stand higher temperatures

New lubricants with flash points in the range, 450 to 550 F, are being developed by Shell Development and Monsanto Chemical.

These are polyphenyl ethers with pour points of 10 to 40 F and viscosities at 210 F ranging from 6.3 to 13.4 centistokes, roughly comparable to viscosity of SAE 20 and SAE 60. But while the SAE oils decompose at 600 F, the new materials have thermal decomposition points well above 800 F. In radiation resistance, the difference is even greater—the new oils are nearly twice as resistant as the standard types.

In lubricity, the new oils are reported "as good as mineral oils of comparable viscosity at the operating temperature." Wear on spur gears is similar to that in mineral oils—practically zero up to the load-carrying capacity of the oil when adjustment of the tooth profile is made after application of load increments.

A full report on the latest tests is being made by Shell scientists to the ASLE. Earlier reports—concentrating on radiation resistance and chemical makeup—have appeared in American Chemical Society publications. (Look for more on these unusual fluids and their engineering application in next week's issue.)

Production blamed for shaft seal failures

"Manufacturing excesses" must shoulder the blame for a large number of shaft seal failures, says GM's research lab after a 3-yr study of lip seal leakage.

Using special testing machines, GM researchers found that improper fitting of seals to shafts, variations in rubber composition and molding technique, and the finish of the shaft itself could all lead to early failure.

In one case, a seal with high trim interference and moderate lip pressure mounted on a smooth shaft (2-microinch finish) showed high torque and severe flutter and was headed for early failure. Relocating it to a shaft that had a rougher (10-microin) finish cured the difficulty. The explanation: The first shaft was too smooth to support a sealing and cushioning oil film at high pressures.

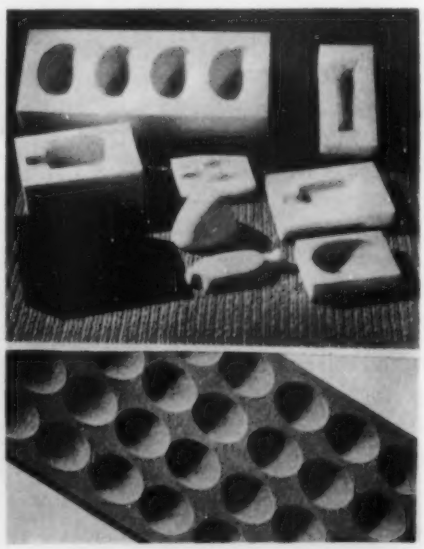
On the other hand, a shaft that is too rough can actually promote leakage, just by providing minute grooves through which the oil simply drains out.

GM's over-all solution is wider use of the two testing machines, in production as well as in R & D. Information on them may be obtained from T. C. Van Degrift, Special Problems Dept, Research Laboratories, General Motors Corp, Warren, Mich.

New low-cost way to form urethane foam

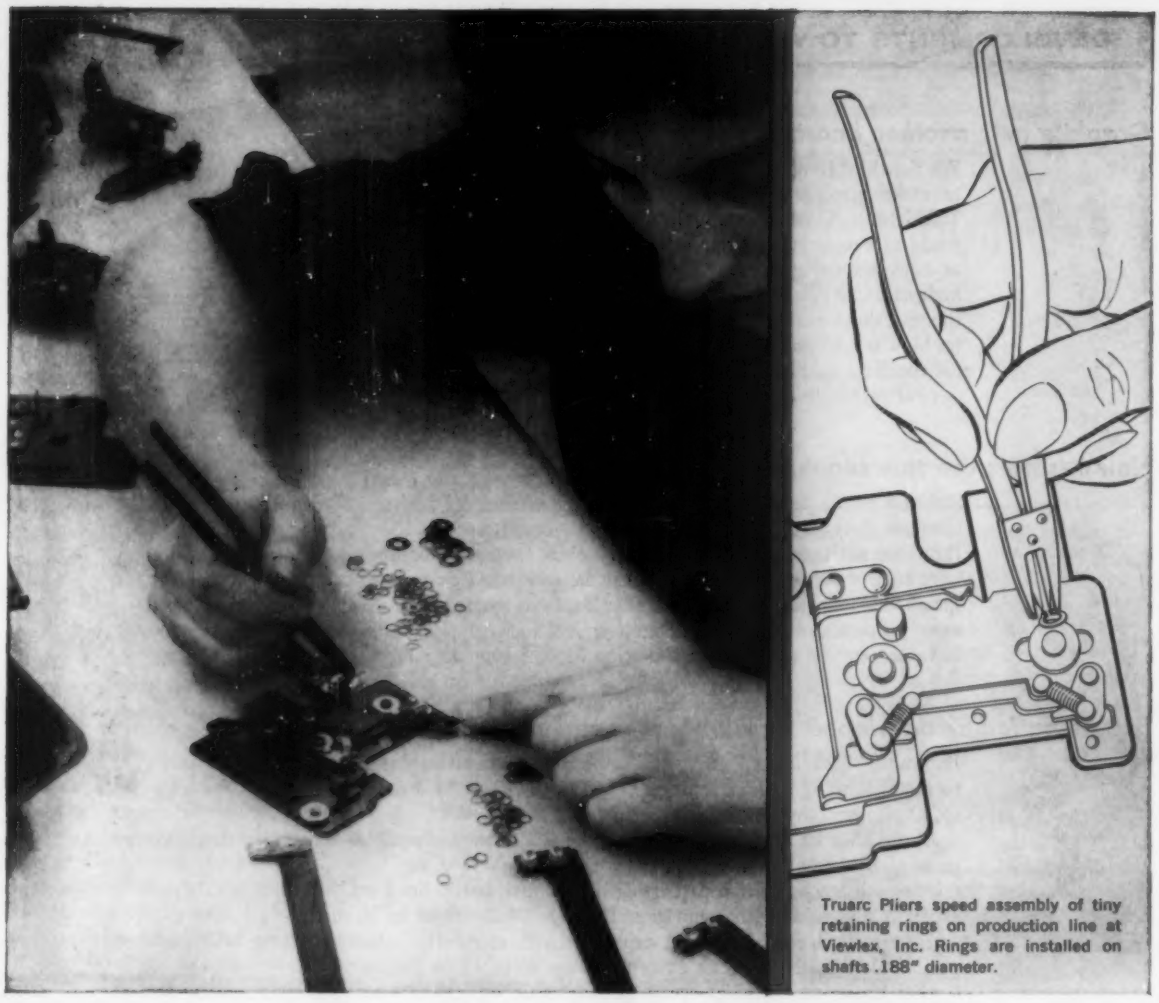
A process that cuts the cost of forming resilient foamed-urethane plastic parts about one-third is claimed by Air-O-Plastik Corp, Union City, NJ.

It's a compression-cutting technique. The foam is first pressed or deformed with dies, then cut while under compression, snapping out when the pressure is relieved to form the desired shape. Air-O-Plastik has developed equipment to perform the necessary operations automatically, is now ready to produce parts to specifications. Among the first: A contoured piece that acts as a combination spring and acoustical barrier in headphone sets.



VARIETY OF SHAPES producible by new compression-cutting technique are illustrated here. Rounded pyramid in center is similar to part used in military headphones.

continued on page 8



Truarc Pliers speed assembly of tiny retaining rings on production line at Viewlex, Inc. Rings are installed on shafts .188" diameter.

Truarc rings eliminate rejects, cut assembly time 40%

Production engineers at Viewlex, Inc., Long Island City, N.Y., save time, speed work with Waldes Truarc retaining rings.

On Viewlex Instruct-O-Matic automatic slide projector, the top plate assembly utilizes five Truarc Series 5100-18 external rings to secure the lost motion plate to the base.

Operator above uses Truarc Standard Plier No. 0018 for installation and removal of rings in accurately located grooves, pre-cut before the assembly is made. Precision engineered plier tips grasp tiny rings securely to speed assembly and disassembly. Pliers are pre-set to avoid over-spreading the rings.

The original design of the unit called for shoulder rivets. In addition to requiring a longer stud, the rivets were difficult to control for height consistency. As a result, when the rivets were flattened, binding or looseness between the plates often caused expensive rejects. For maintenance of the unit, it was necessary to scrap the entire assembly.

Use of Truarc rings assures precise seating of the plates and eliminates rejects caused by faulty riveting. Result: an assembly time saving of 40% at Viewlex. Use of Truarc rings may achieve similar or greater savings—in labor, machining or parts—on your production lines. These versatile fasteners come in 50 functionally different types, as many as 97 sizes within a type, 6 metals, 13 finishes.

They replace nuts and bolts, machined shoulders, threaded collars and set screws, bowed washers or springs and cotter pins, and other fasteners and fastening operations. (A wide line of semi-automatic and manual Truarc tools are available to speed ring assembly). For facts on the entire line of rings, tools and application ideas, write for the new Waldes Truarc catalogs: RR 10-58 and AT 10-58. Waldes Kohinoor, Inc., 47-16 Austel Place, Long Island City 1, N.Y. 9.16

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Graphite gets another boost

For the third time in as many months, a new process has been announced that promises to make graphite a first-class structural material for high-temperature assignments. The latest: A ceramic-type hot-working process which, says National Carbon Co, produces a recrystallized graphite with "two to three times the high-temperature strength of conventional graphites." The material, NCC says, is usable to temperatures as high as 5500 F, can be made in almost any size, and shows better machinability and thermal shock resistance than pyrolitic graphite, while attaining a comparable density (as high as 2.16 gm/cc). Development is now underway to produce a range of materials for specific applications.

(For earlier developments mentioned above, see *PE*—July 18, p 9, and Aug 22, p 8.)

New resistors use thin titanium films

Stable high-temperature resistors are being produced by chemical deposition of thin titanium films on ceramic bases, Lockheed Aircraft reports. Using a fused-salt technique, thin films with resistance values to 2000 ohms/sq cm, stable from −65 to at least 450 F have been achieved, and resistance can be controlled during the production to achieve specific values. R. A. Quinn of Lockheed has prepared a full report on the development for presentation to the Electrochemical Society. (For information on new ceramic high-temperature resistors, see *PE*—Sep 12, p 8.)

Exploding lamps developed for ultrahigh-speed photography

Explosive "flash lights," using the same sheet explosives that have opened new paths to metal forming and hardening (*PE*—Dec 5 '58, p 5) are being developed for high-speed photography.

At the SMPTE High-speed Photography Conference, several US researchers described units of this type.

One such lamp is a transparent plastic cylinder, partly lined on the inside with sheet explosive and filled with argon gas. It reaches full output in 10 microsec.

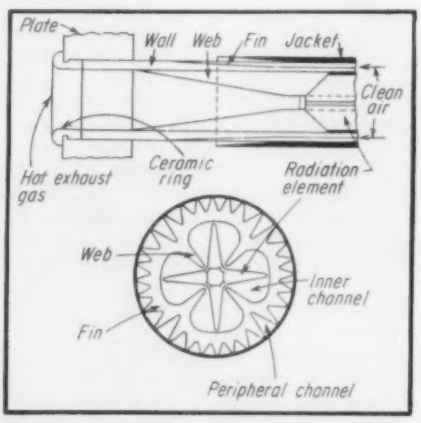
Another type combines sheet explosives with aluminized plastic sheeting to make a pyramidal "candle" that can cover the range from 10 to 200 microsec.

(For more on ultrahigh-speed photographic equipment and its applications, see *PE*—Aug 22, p 29.)

Czechs give heat-exchanger tubes a new shape

For operation at temperatures to 1830 F and pressures to 140 psi, Czech engineers have designed a tube cross-section for a heat exchanger which, they say, can be made of inexpensive materials.

The section looks much like a four-leaf clover with scallops. The "clover" is produced by a series of webs that extend inward from the body of the unit (see diagram), and additional heat-transfer area can be provided by a star-shaped central element whose arms extend into the clover channels. The outer flow space is also provided with fins to produce a convoluted shape, and the jacket itself is finned to increase heat dissipation. The webs and fins also help to strengthen the unit and permit it to stand relatively large pressure differentials. —ARG



FINNED TUBES can be used where pressure differentials are high. Webbed structure is designed to increase strength and promote heat transfer.

WHAT'S HAPPENING IN RESEARCH...

New instruments for testing thickness

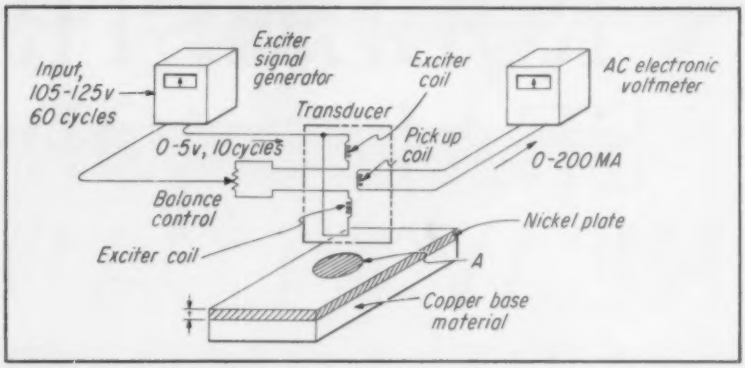
Two new approaches to the problem of measuring thickness of nonmagnetic and paramagnetic coatings on nonmagnetic bases are reported by Paul Dick, engineer with GE's Missile & Space Vehicle Dept.

One unit operates on the principle of magnetic reluctance. It takes advantage of the fact that a surface of a paramagnetic material, when brought within the field of a balanced transducer, will unbalance the transducer and produce an output voltage proportional to thickness of the material.

The other unit employs the magnetic-saturation theory. It has a U-shape electromagnetic probe, a constant-current generator, and an electronic measuring and indicating meter. The probe is, in effect, a transformer with a magnetic open circuit. When its two poles are placed on a paramagnetic surface, the circuit is completed, producing a voltage in the secondary winding of the transformer that is proportional to thickness of the coating.

The first instrument, Dick says, has a range of 0 to 0.40 in. and is accurate to ±2% of scale. The second has a range of 0 to 0.20 and is accurate to ±5% of scale.

A detailed report on design of the units is to be published in the *P.G.I.E. Proceedings* of the IRE.



NEW THICKNESS TESTER is essentially an electromagnet having two differentially wound exciter coils and a single pickup coil. Area marked *A* is the magnetic region that is under test by the instrument probe.

More atoms for research

New radioisotopes, and old research standbys at lower cost, are promised by three recent developments:

• The Atomic Energy Commission is cutting the price of radioactive cobalt (cobalt 60) to $1 per curie on orders of 100,000 curies or more; and is offering discounts of 25 and 50% from the regular price ($2 to $4) per curie on orders totaling at least 5000 curies (specific activity of the materials available ranges from 1 to 50 curies per gram).

• Martin Co announces that a new purification process is expected to make the transuranium element curium 242 available for auxiliary power production in the near future "in larger quantities than have ever been available before in the US." There won't be a lot of it. But there will be enough for research.

• Abbott Laboratories is arranging for direct production of Iodine 131 by irradiation of tellurium), expects to be selling it at 20% under present prices. Material now available is a reactor (uranium fission) byproduct, is difficult and costly to separate.

Radiation-opaque gases to protect spacecraft

Spacecraft that spit out gaseous thermal shields as they fly are foreseen by NASA engineers.

At Lewis Research Center, they've been studying the possibility of ejecting a radiation-opaque gas to shield aircraft from the heat generated in the shock layer ahead of the nosecone.

To do the job, says J. T. Howe of LRC, a gas will be needed that would have a radiation absorption coefficient 3 to 5 times better than that of water vapor and 10 times as good as carbon dioxide.

At least one such gas does exist, cesium vapor; and there should be others. Very little has been done so far on measuring the absorption properties of even the commonest gases.

Ejection of such a gas would reduce radioactive heat transfer to the vehicle; but the gas itself would become hot, and there would be a thermal gradient that would increase convective heat transfer to the vehicle. However, he believes, this convective heating would be less than the radiative heating that occurs without the protective gas, and there would be a net saving.

briefs . . .

Yield strength of Inconel X at temperatures to 1400 F can be more than doubled by relatively short, low-temperature aging treatments, Langley Field researchers report.

Almost as good tensile yield and ultimate strength results in the 80- to 1400-F range were achieved with 4-hour treatment at 1400 F as with 20-hour solution-annealing.

However, for applications requiring lowest creep rates at temperatures of 1200 to 1400 F for long periods of time, the more-complex heat treatments may still be required since elongation at these temperatures in samples given short-term aging was relatively low.

A "chunk" effect explains the variation in corrosion rate of steel when a current is applied from an external source, say G. A. Marsh and E. Schaschl, of the Pure Oil Research Center. They told last week's Electrochemical Society meeting that they believe corrosion under such conditions proceeds partly at least by removal of chunks of metal, rather than just one atom at a time; and this chunk effect may account for more than 50% of the metal loss. —ARG

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**Tensile Strength at Break, psi	4500	7000	8825	8500	8500
Elongation at Break, %	400	450	480	340	250
Izod Impact Notched ft.-lbs./in.	Flexed	Flexed	Flexed	20	1.2
Split Tear, ASTM-D 470 lbs./linear inch	25	50	155	160	200
***Compression/Deflection, psi @ 5% defl.	250	575	750	1800	6000
Rebound Resilience, %	45	45	40	42	45
Oil Resistance	Good	Excellent	Excellent	Excellent	Excellent
Low Temperature Brittle Point, F.	–80	–80	–80	–80	–80

* Softer compounds ranging from 10 Shore A are also available. ** Samples pulled @ 1 in./minute (elastomer stocks normally pulled @ 20 in./min.) *** Shape Factor—1.0

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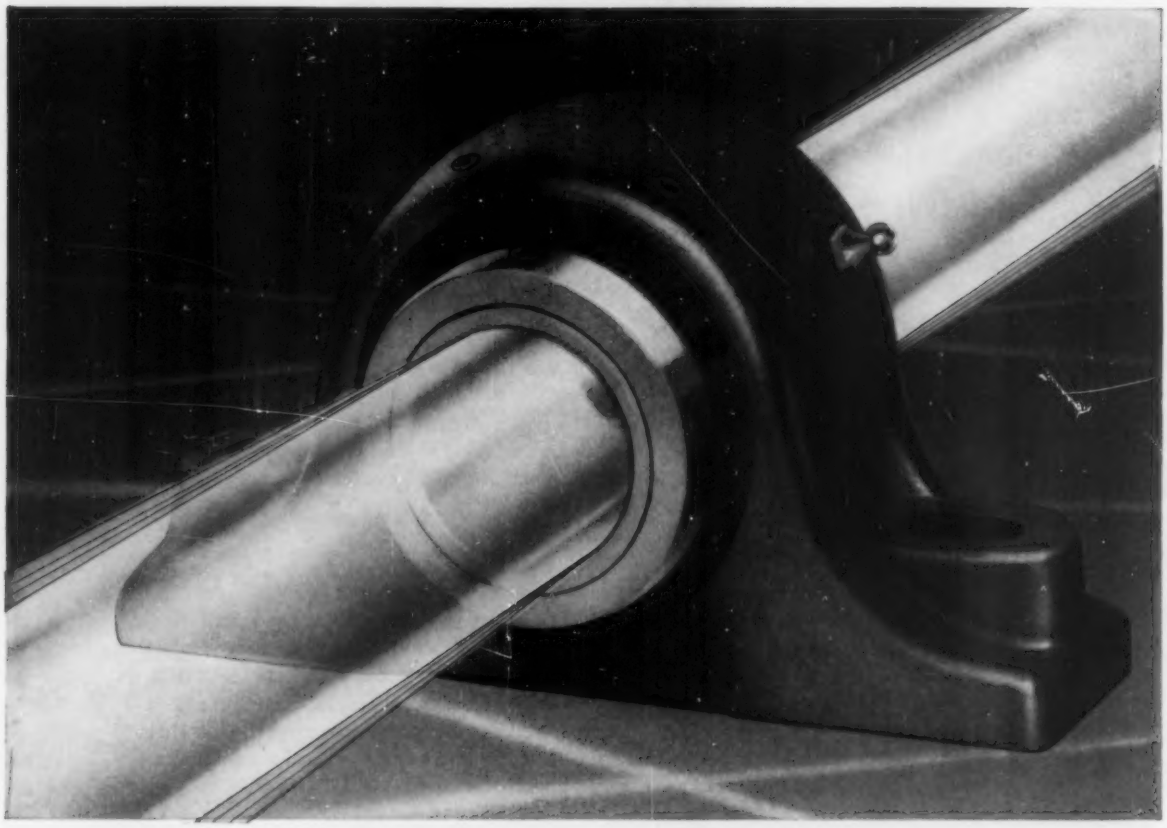

Link-Belt roller bearings compensate for misalignment of shafts and supports

Link-Belt Series 400 roller bearings have won a reputation as "the designer's choice." These self-aligning, double-row roller bearings compensate for inaccuracies in machining and assembly of equipment while maintaining full load capacity throughout their long life. Their compactness promotes simplicity of machinery design—their easy mounting reduces installation costs.

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FROM WASHINGTON . . .

Nuclear power planned for future space exploration

Spending on nuclear rocket engines will rise sharply next year. That is the prediction coming at a time when budgets are being prepared. **Reason is, the government's space experts have made a basic decision—that long-range space exploration programs need nuclear power to be successful. They are planning 10 to 20 years hence for such things as interplanetary space travel. And nuclear power is a must for these plans.**

By 1965, a nuclear engine is due to be tested in space flight. It will likely be another two to three years before they will be in use, however. As planned now, nuclear space rockets will be used as upper stages for launch vehicles with a conventional chemical-fueled first-stage booster.

The big attraction is that almost twice as much thrust can be obtained from nuclear rockets as chemical ones. It means they can carry two to three times as much payload.

Spending on nuclear rockets now runs around $30 million a year. But it is expected to more than triple within the next three to four years.

Active communication satellite in the works

The National Aeronautics and Space Administration may start an active communications-satellite program. The matter is being decided now. **Right now, NASA is experimenting only with passive communications satellites in the Project Echo series. The Army is handling the nation's active communications-satellite program with its Courier and Advent satellite series.** These are satellites that can store and resend messages. Passive satellites are only reflector balloons that serve as an object to bounce signals off of. They don't carry any radio equipment, hence require high-powered ground equipment.

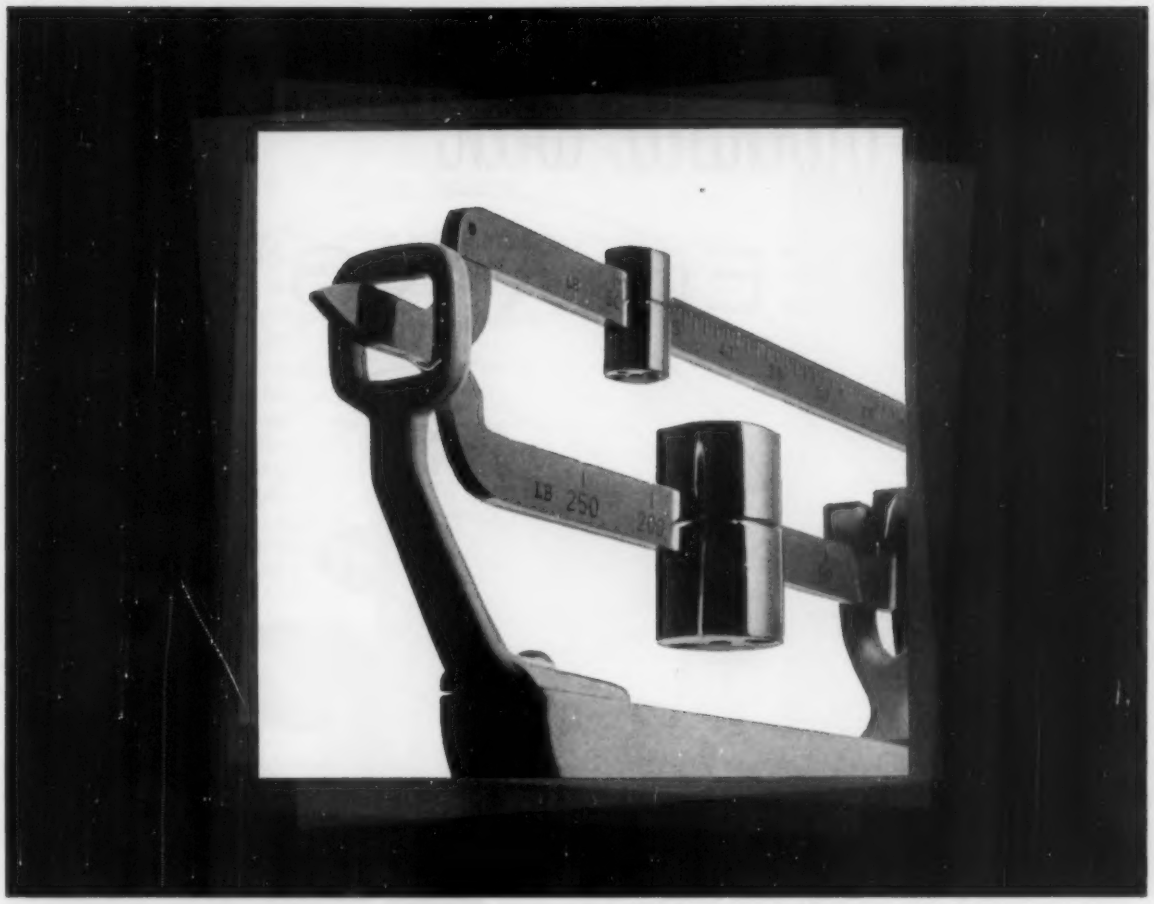
Reason for NASA's move to get an active communications-satellite program is to simplify designs. Unofficially, some NASA engineers argue that military requirements being built into the Army's satellite program are far more than needed for straight commercial-communication satellites. That's why they want to build a stripped-down version.

Manned-aircraft contracts to be let

The Air Force has plans to develop a new fighter-bomber. Contracts for the plane are expected to be let within the next few months. At least $25 million is earmarked for the project in the current budget for initial development.

Known as the "F-X" and also the "F-111," the plane is billed as the "most flexible tactical-type aircraft ever designed." It is to have a takeoff capability within 5000 to 6000 feet; be able to operate off makeshift airstrips; and have an intercontinental range without refueling.

Reports are the plane will have a variable-sweep wing design to allow operations at both low and extremely high speeds. Some reports claim the plane could also be used for aircraft carrier operations.



How to stop your scales from "stuttering"

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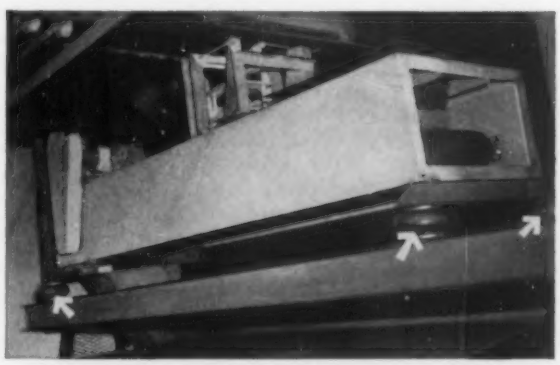

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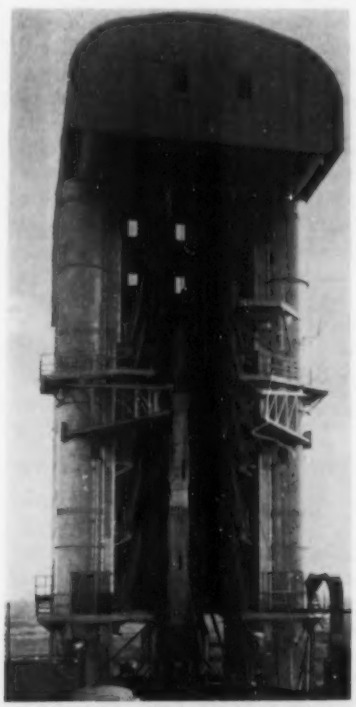
THE ENGINEERING WEEK

Britain Fights for a Place in Space

While the debate on her proper role in space rages on, the UK government is shopping around for Commonwealth or European supporters. If such support is found, the now abandoned Blue Streak rocket may carry research and communication satellites to space.

LONDON—The British government is looking for partners to help support the nation's controversial space program. Negotiations underway in Australia between the Australian government and Peter Thorneycroft, Britain's newly appointed aviation minister, may produce a Commonwealth space club by the end of the year.

Thorneycroft has said, however, that final decision hinges, in part, on concurrent talks with France and West Germany. The British have also asked the 15-nation Council of Europe to consider setting up a European Space Agency. The Council includes Austria, Belgium, Denmark, Greece, Ireland, Iceland, Italy, Luxembourg, Holland, Norway, Sweden and Turkey as well as France, Britain and West Germany. Such a pool could boost greater resources than now available to the US or Russia.



DE HAVILLAND'S BLUE STREAK, shown here in a missile service tower, Spadeadam, Farnborough, England, is similar in size and external appearance to the Atlas. It weighs 200,000 lb and produces thrust, exceeding 270,000 lb, from twin gimbal-mounted rocket engines burning liquid oxygen and kerosene. Both are sustainer engines.

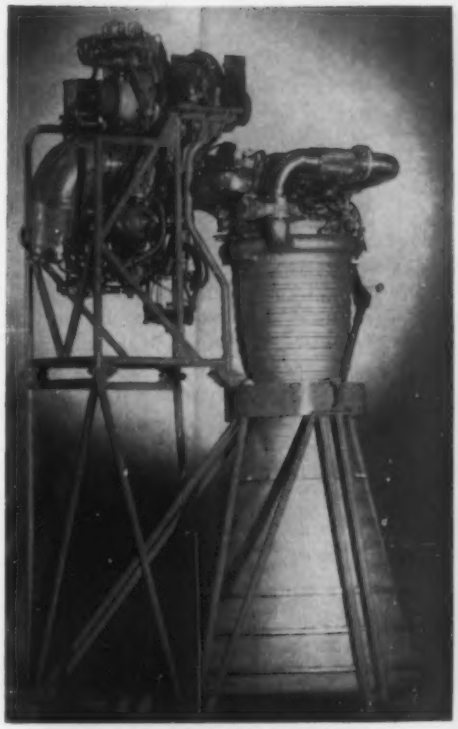
The program under discussion in Australia calls for a 3-stage Blue Streak rocket to be launched from facilities at Woomera, Australia. It would place three satellites in polar orbit to serve as a space-communication system—similar to the one proposed by AT&T. According to reports from Melbourne, the program, which includes both missile and satellite development, would cost about $335 million, spread over 5 years—Bell figures its program, for a satellite system alone will cost $170 million. UK space engineers estimate that most of this would be recovered in 10 years from returns of space communications.

Research applications, combining the Blue Streak for first stage with the Black Knight for the second stage of a three-stage rocket, are likewise under study. One proposal calls for a 2000-lb satellite to orbit near the earth for astronomical observations; a second, weighing several hundred pounds, to orbit at 8-10,000 mi for investigating the earth's magnetic field, atmosphere and radiation environment; and a third for a 50-100 lb satellite to orbit with a 100,000-mi maximum altitude for investigating the sun's atmosphere.

The space-program issue has presented Britain with its worst dilemma since the Suez crisis and the birth of the European Common Market. Like both these events, the decisions involve Britain in the painful task of reappraising her world-power status, about which Britain is still divided.

There are three dominant schools of opinion. One, currently losing favor, suggests Britain stop trying to appear to be a third great world power and concentrate all her R & D on conventional industrial fields. This group denies that technological gains need the stimulus of national missile and rocket programs. It regards the atomic energy and aviation fields as two other status symbols which have cost dearly and should be renounced. The economic growth and technical prowess of Germany, they observe, has been achieved without the stimulus of rocket, aircraft and nuclear industries.

The other schools both realize that Britain cannot be first or biggest in



AMERICAN INFLUENCE — from the Rocketdyne S-3 — is evident in this Rolls-Royce rocket engine. However, the British model is said to include significant improvements, notably in the propellant system. Fuel supply of the Rolls engine has a fast cutoff that enables the missile to dispense with vernier rockets. It retains the conical nozzle that was in use when plans for Blue Streak were completed, rather than the bell chambers used on later Rocketdynes engines.

space but feel she can and must participate for technological reasons of overwhelming merit quite apart from the overtones of prestige and status. These schools diverge only on the scale of a space program. Scientists and engineers disagree over whether Britain should make her own launching vehicles with the collaboration of Europe or the Commonwealth, whether she should buy American launchers and fire them from Woomera or whether she should employ American missiles launched from Canaveral.

Scientists, particularly biologists, maintain that the design and manufacture of launching vehicles will cost more than the technological payoff. They hope savings from the use of American missiles could relieve their miserly budgets.

Engineers maintain that without motivation and stimulation of a rocket program, many important advances having applications in other fields will not be forthcoming. Instead, these advances will be made by America and Russia and used to Britain's disadvantage. And it is unlikely, they add, that the money saved would be reallocated to science.

ENGINEERS SEE MANY NEW PRODUCTS

Emphasizing the engineering viewpoint, Geoffrey Pardoe, chief engineer of DeHavilland's weapon research group, told PRODUCT ENGINEERING that his company has created a division to market an entirely new range of factory process and automation equipment as a result of circuit features which were developed for the Blue Streak countdown equipment.

British engineers are especially opposed to using American launching facilities. Canaveral, they say, is too saturated with America's own space and military missions to handle a British research mission. And later on, when rival commercial concerns compete for launching time needed to establish a space-communications system, the British position will become untenable. They also fear that contracts with the US, particularly if they include an exchange of know-how, will include clauses prohibiting commercial exploitation outside the commonwealth.

Design and testing of the Blue Streak and Black Knight rockets, which are basis for the Woomera talks, are both well advanced. DeHavilland's Blue Streak is a liquid-fuel rocket which unites some US and British design features. Convair's influence is evident in Blue Streak's external structural appearance, though according to Mr Pardoe, the missile is structurally different from its US counterpart in many respects. Manufacturing techniques are similar. The engines, externally, are virtually identical with the American-built Rocketdyne S-3 motor. Rolls has a licensing agreement with Rocketdyne. Guidance details are still highly classified, but the inertial-guidance system appears to be based on a system conceived at the Royal Aircraft Establishment, Farnborough. Sperry Gyroscope Ltd, a wholly owned subsidiary of Sperry Rand, is responsible for guidance.

Blue Streak's rocket motors were test-fired more than 18 months ago. Since then, there have been many successful firings of single and twin units at the nearly completed $70 million rocket test and development center, Spadeadam.

The Black Knight is an entirely British liquid-fuel rocket developed by the Royal Aircraft Establishment. It is powered by a cluster of 4 trunnion-mounted Armstrong-Siddeley Gamma rockets totaling 20,000-lb thrust, and has been used with outstanding success to heights of 500 mi as the reentry vehicle for the Blue Streak program. Every firing of the vehicle and its subsequent recovery is claimed to have been completely successful in all respects.

In the proposed research vehicle, the Blue Streak itself would need little modification beyond nose changes to attach the second stage. The inertial-guidance system, which becomes superfluous, would be replaced by an entirely British guidance system. This system has already been developed and its components tested. The Black Knight could serve substantially unmodified as a second stage. In its space role, the rocket would have greatly reduced slimness ratio, but would retain the same motors and propellant capacity. The third stage has not been selected.

WHAT PRICE SPACE?

To date, the Blue Streak missile program has cost the United Kingdom $250 million, and the launching complex at Woomera is reported to have cost the Australian government $150 million. In perspective the proposed annual expenditure on a space program works out to about one-third of the British expenditure on the atom and just matches a subsidy to Britain's egg farmers.

Advocates maintain that missilry is not a formidable item for Britain's taxpayers. But few people, particularly the Treasury, are confident of estimates prepared by Britain's missile industry. Too often, official cost estimates for many of Britain's missiles have proved minute fractions of the mighty sums that have ultimately been expended. The British treasury revealed in March this year that the first generation of three missiles, estimated to cost $22.4 million, in fact cost $308 million—a 12-fold increase.

—John Tunstall, London Bureau

Arc Lamp Tests Experimental Rocket Liners

AKRON, OHIO—Carbon-arc lamps are being used to test experimental rocket liners developed by the Research Div of Goodyear Tire and Rubber Co. The project is aimed at perfecting lightweight high-insulating rubber liners for fuel casings of huge rockets. They must also be flexible enough to conform to the distortion the casings undergo from the pressure of combustion gases.

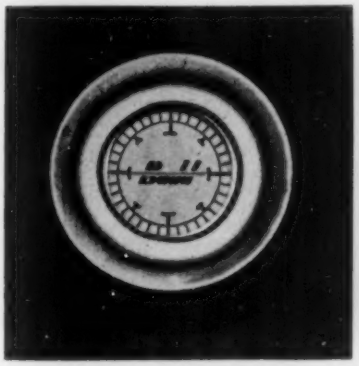
SIMULATES FLIGHT HEAT

A carbon-arc image furnace, which can generate heat beams of 6500 F, duplicates the heat which the liners will encounter in flight. The installation bounces heat beams off two ellipsoidal mirrors that focus on the specimen being tested. Control of the beams is said to be precise. Because radiated heat can pass through glass, the gaseous byproducts of the heating process can be studied by testing the specimen in closed containers.

Liner samples found satisfactory are then further tested in a stationary rocket. Sensitive instruments wired to the liner samples register the resistance of the samples to heat and thrust erosion under actual flight conditions. ■

Photoelastic Rosette Separates Principal Strains Directly

PHOENIXVILLE, PENNA — Strains "frozen" in place are the key to a new photoelastic starin rosette that provides direct readout of principal strain directions and separate strain magnitudes. Developed by the Budd Company's Instruments Div, the new PhotoStress rosette is a disk with a circular hole at its center. A symmetrical strain system is imposed (by hydrostatic pressure, for example) on the disk material while it is at elevated temperature. Cooling the photoelastic material with these loads in place locks or "freezes" a predetermined circular fringe pattern into the disk.



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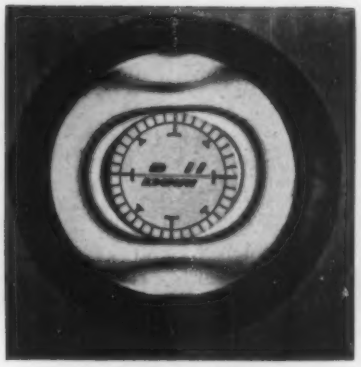


LOAD APPLIED

To measure strains in a metal structure, the photoelastic model is attached with any common strain-gage cement. The rosette then absorbs the strains applied to the structure and indicates them by displacement and distortion of the fringe pattern locked in the rosette (photos above). Directions of principal strain are indicated by axes of symmetry of the distorted pattern. Gage is designed so that separate principal strains are directly proportional to fringe movement along these axes. The movement is measured with a scale.

Direct separation of principal strains, as performed by the new gage, is a departure from conventional photoelastic analysis. Conventionally, fringe movement under normal light incidence measures the difference in principal strains. Another relationship between these strains must then be determined by some other method, usually measurement of fringe movement under oblique light incidence. (For additional details on how the photoelectric rosette works, see next week's article coming in PE.)

—Ford R Park

Hydrofoiled Again—This Time at 70 mph

This 23-ft gas-turbine-propelled hydrofoil vessel, designed to reach 70 mph, is intended to be the fastest hydrofoil craft in existence. Called the XCH-6 and developed by Grumman Aircraft's Dynamic Developments subsidiary for the Office of Naval Research, the craft utilizes "super-cavitational" principles. (A vapor cavity exists in the water around the surface of a moving craft, and works against an increase in speed. With super-cavitational propellers and foils, the cavity effect is reversed to result in increased speed.) Its basic system includes two main foils, forward of the center of gravity, that support 75% of the weight of the boat; and one fully submerged rear foil in the stern of the boat, which supports the remaining 25%. The two main foils are "surface piercing," are inherently stable, and can be extracted from the water and folded up. The VCH-6 also uses a super-cavitating propeller driven by an over-the-stern, right-angle driveshaft linked to a 1000-hp GE gas-turbine engine. Mating of the lightweight engine and the super-cavitating propeller provides ample thrust.

See CL-44's Sold by Canada

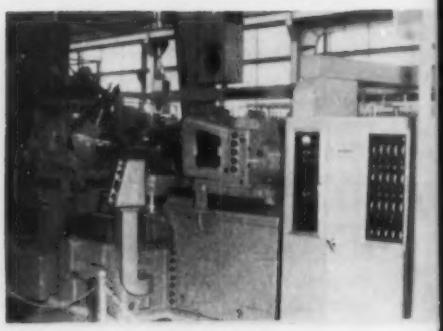
WASHINGTON — The Defense Dept confirms that a Canadian offer to sell CL-44 aircraft to the US Air Force is "under study." No details of the Canadian proposal, however, are available.

But there are two rumors going the rounds here on what the deal would involve. One is that Canada, in return for the CL-44's, would either buy outright US radar installations and related electronics facilities in the Canadian arctic or assume the cost for operating the bulk of the radar warning line there. The other is that no swapping would be involved, that the CL-44 planes would be sold to the Air Force directly.

So far there's no sign of any Pentagon decision on the proposal.

There is money available in the Air Force's budget for the CL-44 planes. Congress added $194 million to the budget for procurement of transport planes—part of it for Douglas C-130E aircraft and part for Boeing's C-135 "or an aircraft of similar capability. ■

FIRST PUBLIC SHOWING of a tape-controlled coordinate drafting machine exhibited by Dennert & Pape of Hamburg. Using punched tape, this $25,000-machine produces the highly accurate drawings required for optical projectors for the inspection of workpiece contours. In principle, the digitizers overlay the drawing area with an electrical rectangular grid net. The plan position of all accessible coordinate points is always the point of intersection of two determinate lines within the grid, and any pair of lines can be chosen as reference axes for *X* and *Y* directions. Instrument orients its motions from these axes.



FEATURES OF THIS BORING, drilling, reaming and facing machine built by Burkhardt & Weber, Reutlingen, are automatic positioning in three directions, and automatic tool change from a 30-tool magazine. A decimal code is used for workpiece positioning and a binary system for tool and auxiliary functions. A tape-controlled arm removes one tool from the spindle and replaces it with another selected from the magazine drum. Time taken for a complete tool change: less than three seconds. Other features: preselection of 28 spindle speeds, 31 different feed rates, plus automatic indexing of the table to any of 15 positions. Machine is Europe's answer to Kearney & Trecker's "Milwaukee-Matic." Tape control unit is built by Hughes Aircraft Co who will later install it in its San Diego plant.

German Machine-toolmakers Jockey for More of the Market

HANNOVER — West Germany's machine-tool industry appears to be the prime mover in a trend away from all-European machine-tool exhibitions and toward shows staged by individual nations. At the next meeting of The European Committee (organizers of the biennial European Shows held in France, Germany, Italy and Belgium) some members will press for a lengthening of the interval to 5 years while others will ask that the shows be discontinued after 1963.

But if the national shows are to effectively replace the continental ventures, it's felt that organizing committees of the various countries should at least seek to coordinate scheduling to avoid conflicting dates; Germany's Hannover show, the French exhibit in Paris and the US show in Chicago were conducted concurrently.

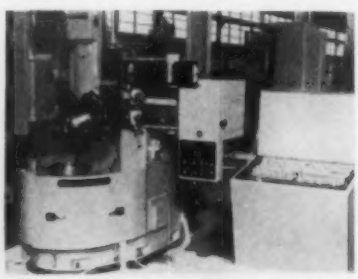
Officially the reason given by the German Machine Tool Assn for inaugurating its own exhibitions with the one at Hannover this year was that its members were dissatisfied with the space-squeezing, weight-limiting conditions that were met at the European exhibition held last year in Paris. By staging an exhibition of their own (see photos on this page), the German machine-tool makers could show a full range of machines without having to fight with other countrys' manufacturers for exhibition space.

Here, about 750 exhibitors were accommodated in 9 large halls which in 1957 were used by well over 1000 exhibitors. Of the 125 foreign exhibitors, most were Swiss and Italian with a smattering of French, British and Dutch. No Iron Curtain countries exhibited though they were in attendance at the French exhibition (*PE—Oct 10, p 17*). To keep US firms completely out of Hannover, the exhibition management imposed a makers-only restriction which effectively froze out those European firms handling US machines. As US machine-tool makers are already barred from participating at German shows, this new ruling seems aimed at keeping American equipment at arm's length.

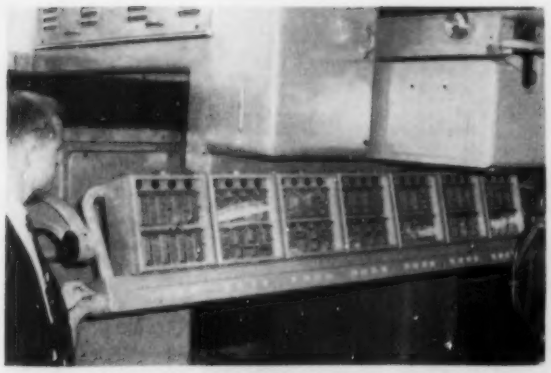
With Hannover admittedly the top machine-tool show on the European mainland, the Germans may turn their attention to the UK show at Olympia before initiating a campaign against our Chicago exhibition. The Germans are not content to supply the world with well over one-third of its machine-tool requirements. They want Hannover eventually to be stamped as the only worthwhile place in the world for a comprehensive selection of machine tools.

ON DISPLAY

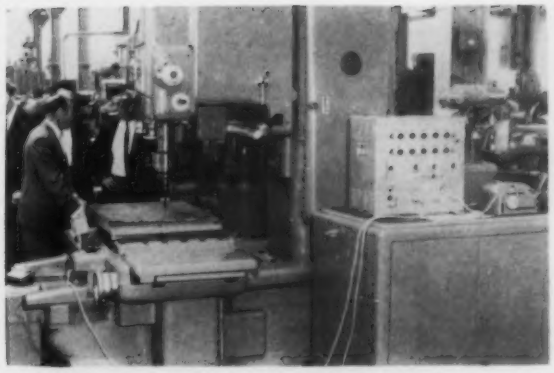
At the Hannover show, the crowds were drawn by a wide variety of machines equipped with automatic loading and unloading. After having overcome earlier mechanical and functional troubles, manufacturers appear to have advanced along similar development lines. More or less basic types of automatic loaders engineered



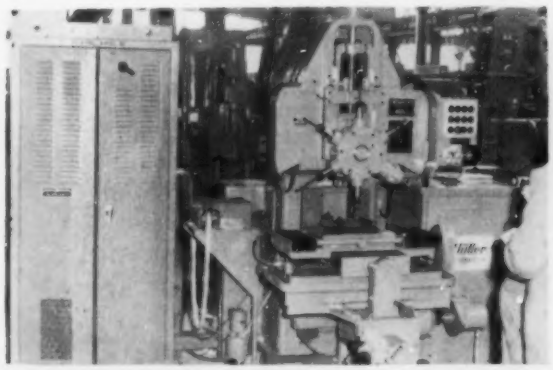
DOUBLE-COLUMN VERTICAL BORING MILL by Schiess of Duesseldorf. Tool is equipped with a program device to provide completely automatic control. After setting stop blocks on vertical and horizontal rod assemblies, and setting up programing board in its individual console, the full machining cycle including feed selection and change, speed selection and change, head movements, turret indexes, and all other necessary functions for machining, are automatically controlled.



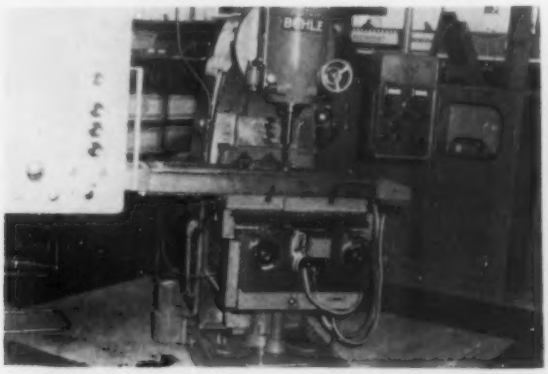
LONG LINE OF PLUGBOARDS belong to this coordinate boring and milling machine built by Berliner Maschinenbau of Berlin with automatic spindle positioning. The standard machine as shown at Hannover includes coordinate preselector, automatic precision positioning of spindle, program control with coordinate point storage, and automatic work cycle. The outstanding extra feature of this machine is that its programing control offers progressive steps to full control by simply adding building-block control elements.



THIS JIG BORER made by Kolb of Cologne is fitted with a prototype tape control developed by the Aachen Institute of Technology. The fully transistorized axis-control system functions with optical gratings. Two parallel, graduated glass scales are fitted on the table of the machine so that a light impulse is given when graduations of the scales pass over and under each other. Aachen engineers consider that a 2-axis tape control unit could be built for about $4000.



HUELLER OF LUDWIGSBURG showed the Burgmaster turret drill with GEC tape control. The drill unit is built under license in Germany so that it can be shown at Hannover without breaking the "makers-only" restriction on exhibitors. The Burgmaster 6-spindle turret drill is an intermediate-size machine with three-axis tape control by GEC numerical control equipment. Indexing accuracy of turret from spindle to spindle is less than 0.00015 inches.



MILLING MACHINE by Bohle of Bielefeld was designed for use with tape or plugboard control. The Lorenz reader and control system utilizes 5-channel tape as against the 8-channel variety used predominantly in the US.

to fit certain types of machines or to handle a specific component shape have emerged. This has had a tendency to standardize the market.

TRANSFER-MACHINE MARKET

Use of transfer machines has not spread so rapidly as some prophesied back in the early 1950s. This is because of Europe's relatively small production quantity needs. Linked lines, though, have gained a great deal of ground and some of the configurations exhibited here evidenced how capital investment can be kept reasonably low, and a high degree of flexibility maintained by using standard machines, standard automatic loading and unloading devices, and standard conveyor equipment between individual machines.

Ceramic tooling has not caught on in Germany but some very high speeds engineered into some of the newer machines suggest that manufacturers are not writing off this kind of tooling as a complete loss.

—Jim Morrison, Bonn Bureau

Soviet Starts University for Foreigners

Moscow—Friendship Univ, the Soviet Union's new educational headquarters for students from underdeveloped countries opened Oct 1 as scheduled (*PE—July 25, p 15*). This is the Soviet attempt to attract a large number of foreign students, by building a special university for them rather than send them to Moscow Univ.

The initial class includes students from Cuba, Nigeria, Uganda, the Congo, Mexico, Ceylon, Mali, India and some Soviet republics. Before going on to their chosen curriculum all will study Russian. ■

LIFESAVER PROJECTILE is designed to be gas-propelled as far as 250 yards to a swimmer in difficulty or a man overboard. Consists of two aluminum shells that contain inflatable vinyl raft 12 x 24 in. Nose section houses a firing mechanism which, upon impact with water, breaks two capsules of CO_2, inflating raft. Will stay afloat a minimum of 8 hr and was designed by (from left) Marshall Corroza and Thomas G. Dulin, Philadelphia Museum College of Art, to support at least two people weighing up to 250 lb each.

ALCOA'S SECOND ANNUAL STUDENT AWARDS

This year awards were made to six students of industrial design by Aluminum Co of America. Each of the winning entries is from a different school, and represents each faculty's judgment of the best solution to a design project: the development of a feasible product entailing the use of aluminum.

Here are the six winners, with their schools and their winning designs:

MARSHALL CORRAZZA, THOMAS DULIN, *Philadelphia Museum College of Art, life-saver projectile*

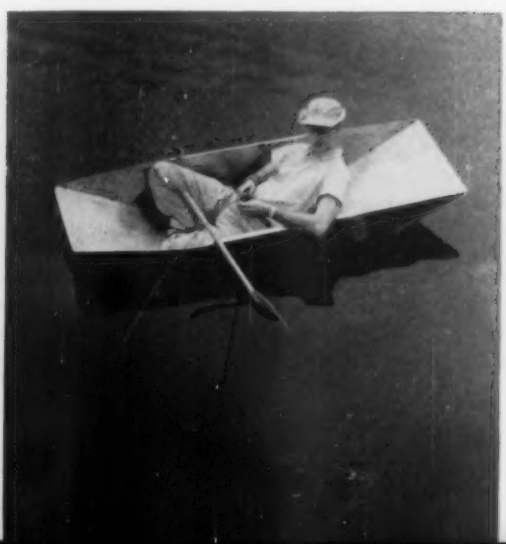
S JACK MAGRI, *Syracuse, water sports vehicle*

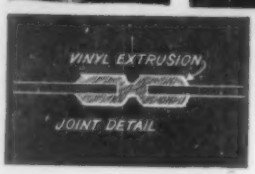
DALLAS MOLERIN, *University of Bridgeport, shelter*

ANDROUS D NOYES, *Pratt Institute, modular swimming pool*

TAKATSUGU SUGIYAMA, *Illinois Institute of Technology, ribbon chair*

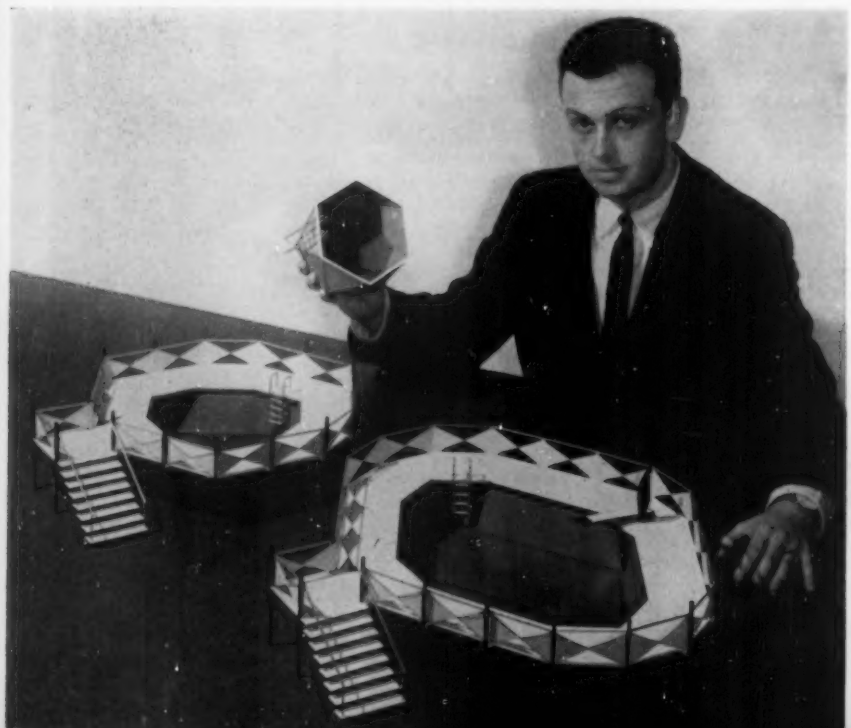
JOHN E THOMSON, *University of Illinois, collapsible boat*





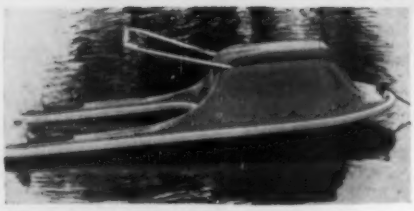
DESIGNED FOR FISHING in quiet waters normally inaccessible for a boat, the "Polliwog" weighs 27 lb and folds to a size roughly comparable to a two-suiter. It is constructed of aluminum sheet bonded to vinyl (see sketch). John E. Thomson, the designer, graduated last August from the University of Illinois, is shown here carrying, opening, and using his craft.

SHELTER for as many as four adults has storage capacity for a two-week's supply of minimum necessities. Consists of two accordion-pleated shells, which can be used separately or with space between filled with foamed-in-place insulation. Can be buried with only entrance hatch showing, partially buried or tied down for anchoring, or simply set down on open ground. Can be shipped knocked down or transported to site fully assembled and provisioned by helicopter. By Dallas Molerin, University of Bridgeport.



MODULAR SWIMMING POOL is expandable and can be disassembled for moving. Consists of two aluminum-sheet modules, an equilateral triangle and rectangle. These are joined by bending edges 90°, butting them and fastening them together mechanically, using a gasket-type seal. Androus D. Noyes, Pratt Institute, designed this pool for above-ground installation.

continued next page



INTENDED FOR WATER SPORTS and as an offshore operating base for skin divers, top and bottom aluminum shells of this vehicle also enclose its outboard motor. By S. Jack Magri of University of Syracuse.

RIBBON CHAIR was designed to be fabricated from continuous aluminum strip, with a minimum of scrap. Material is ⅛-in-thick 6061 sheet, T4 or T6 temper. Takatsugu Sugiyama, now graduated from Illinois Institute of Technology, has returned to Japan and is presently working as a designer there.

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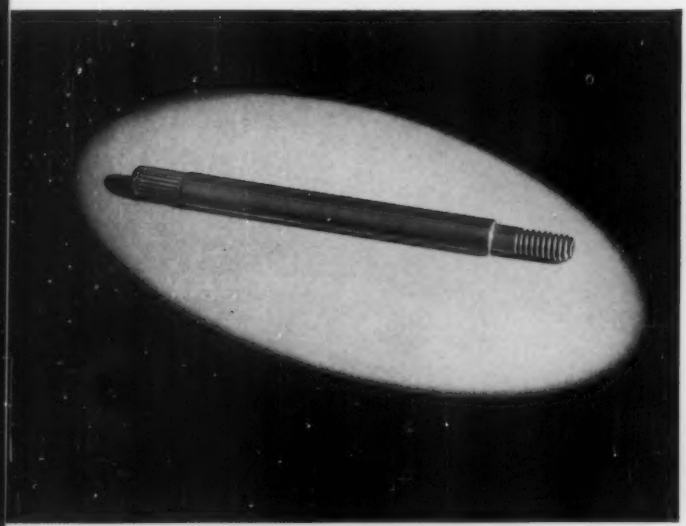

WHIRLPOOL CORPORATION uses .314″ diameter Republic Cold Drawn Stainless Steel Bars (Type 416) for water pump impeller shafts in 1960 RCA Whirlpool Dishwashers. Shafts are turned and threaded on one end, knurled on the other, cadmium plated, and pressed into die cast impellers. Republic produces more than 40 standard types of stainless steel. Send for these free booklets: (1) HOW TO FABRICATE . . . (2) HOW TO WELD . . . (3) HOW TO MACHINE . . . Republic Stainless Steel.

THE CRANE CO. used Republic Titanium in the production of valve components for Freeport Nickel Company's new $119,000,000 nickel-cobalt processing facilities. Titanium was cut, ground, tapped, spot welded, heat treated, and hand forged. Use of Republic Titanium permitted close-tolerance machining with considerably fewer rejects than anticipated. Titanium metallurgists help you select and apply the grade best suited for your needs. Send for data.

3-DIMENSIONAL METALLURGICAL TEAMS:

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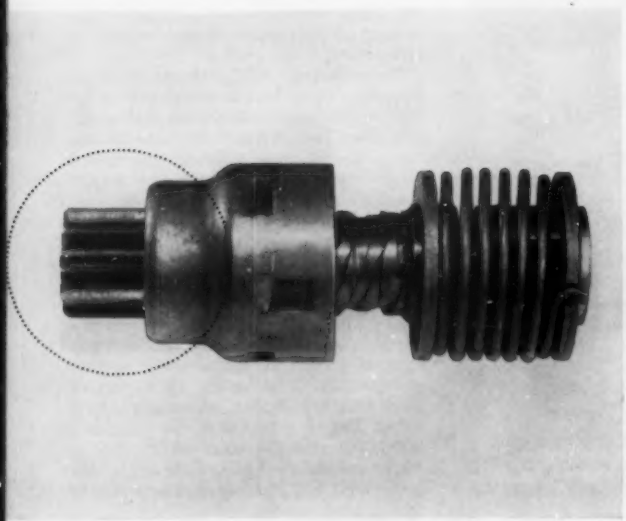
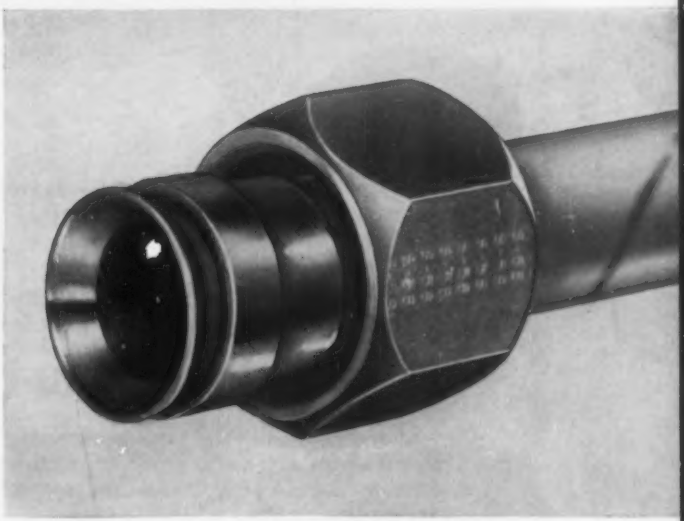
(for Whirlpool...for Crane ...for Eclipse...for you)





ECLIPSE MACHINE DIVISION, The Bendix Corporation, uses Republic Cold Drawn Alloy Steel in the production of drive pinions for automobile starters. Type 8617 bars are blanked, hobbed, chamfered, and drilled. Teeth are cut on a gear hobber and pointed for easy meshing with the flywheel. This cold drawn alloy gives Eclipse better machinability . . . reasonable cost . . . added strength and dependability. Send for details.

HUNDREDS OF EQUIPMENT BUILDERS have switched to Republic ELECTRUNITE® Hydraulic Fluid Line Tubing. This *welded* tubing is easier to flare and bend . . . meets or exceeds the normal life of tubing produced by any other method . . . offers appreciable savings in initial cost. Available in all sizes shown in the JIC Standards Book. ELECTRUNITE is made from close-tolerance, flat-rolled steel. Checked for defects as only flat-rolled steel can be checked. Send coupon for copy of specifications.

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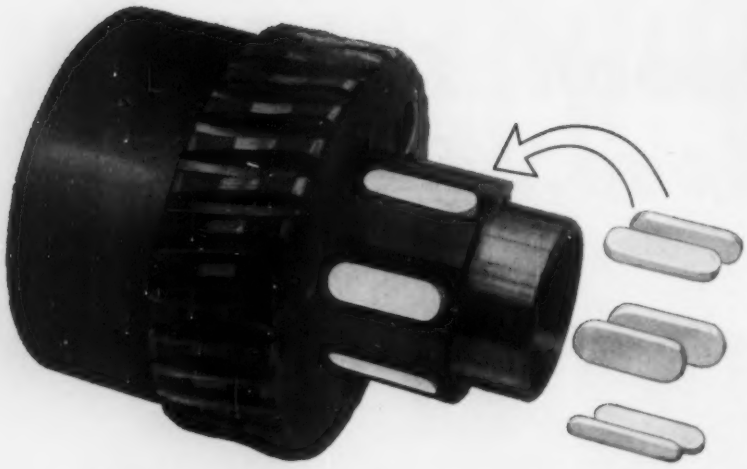

Roll clutch cam section of automatic screw machine. Six inserts of Kennametal Grade K92 are used at point of great impact.

In roll clutch cam section . . .

KENNAMETAL* Grade K92 inserts outlast steel 8 to 1

Carburized and case-hardened *steel* inserts used at a point of great impact on an automatic screw machine were averaging 3.5 months' service. Replacing the inserts was a 4-to-5 hour job for the machine user.

Then, 29 months ago, the manufacturer installed a set of *Kennametal* tungsten carbide inserts on a machine as a test. The first set installed is still going strong, and has eliminated more than 30 hours' downtime.

Recognizing how much customers would welcome this outstanding decrease in maintenance, this customer now uses Kennametal inserts as original equipment and replacement service parts for this model. In addition, plans have been made to extend the use of Kennametal for wear parts on other machines they manufacture.

The Kennametal family of hard carbide compositions contains many different grades. In this application, Kennametal Grade K92 was selected for its medium hardness (87.5 RA) and high transverse rupture strength (385,000 psi). Chances are K92, or one of the other Kennametal Grades, can solve one of *your* machine design problems. Why not find out more about this metal that has remarkable resistance to impact, abrasion, corrosion, extreme temperatures and pressures. Contact your Kennametal Representative or write us direct for Bulletin B-111-B, "Properties of Kennametal," and Bulletin B-666, "Proven Uses of Kennametal and Kentanium."* KENNAMETAL INC., Department PE, Latrobe, Pennsylvania.

*Kennametal is the registered trademark of a series of hard carbide alloys of tungsten, tungsten-titanium and tantalum. Kentanium is the registered trademark for one of the series that has special advantages for applications requiring a lighter weight material, or maximum resistance to temperature extremes. 33520

INDUSTRY AND KENNAMETAL ...Partners in Progress

READER TO EDITOR

Engineers or Indians?— The "Super Chief's" Rebuttal

To the Editor:

I would like to address this letter, Mr Editor, not to you, but to the writers of the letter entitled "Engineering Caste System," in your issue of Sep 19, p 28. Jack Rogers and Robert Sheehan, in this letter, referred to the cover photo on your July 25 issue, which depicted myself and several other members of Marchant's engineering department arranged around a table.

Messrs Rogers and Sheehan wrote a truly humorous interpretation of this photo, describing the "Indians in shirtsleeves" at the left, the "four lesser chiefs, toward the rear . . . in their identical gray-flannel status symbols," and the "Super Chief" (myself) at the right "in full-dress blue-serge paraphernalia." The writers then went on in more serious vein, presenting an articulate plea for elimination of class distinctions, and for better recognition of engineers as true members of management. I would like to say to you, Mr Rogers and Mr Sheehan, that I am very glad that you went to the trouble, in the serious portion of your letter, to express an important point of view which is imperfectly appreciated today, most often by engineers themselves. This is that engineering is fundamentally a planning function, which is the most distinguishing characteristic of management activity.

The decisions that an engineer makes, scores of them daily, have a direct effect upon a whole chain of human activity which follows him. He must, at every point, balance a host of conflicting needs, and somehow resolve them to a usable answer. He must produce a set of decisions (a design) which will: (a) be reliable, so that the customer will be satisfied with the product; (b) be economical to produce, which involves a whole array of subrequirements—that it be easy to make, easy to assemble, and easy to adjust; (c) be easy to service. And he must do all this while constantly bearing in mind that he must also be economical of his own efforts, so that this perfect design may be released from his hands in the absolute minimum of time. In other words, he is subjected, in his daily work, to identically the same pressures as the president of the company, and must resolve them with the same objective in mind: that the organization should perpetuate itself, and produce a profit.

If the engineer fails to do his job right, and does not resolve the conflicts in ways which are consistent with the above objectives, the entire organization wavers and, in the end can even flounder completely. It is the constant demand upon the engineer to make these decisions, *which no one else can make for him*, that stamps him as a true member of management.

I can tell from your letter, that our thinking is identical on this subject. However, your letter only presented the basic complaint against class distinctions, and

failed to offer practical means by which your objectives might be achieved. I am certain you do not visualize a world in which every person receives an identical compensation, regardless of contribution, or where no person ever possesses even the slightest item which might be interpreted as a status symbol. Such a world would not be real, and therefore I am sure you recognize that there *must* be differences. These differences can only be based upon level of contribution, which in turn is controlled by a large array of other factors. Some of the more obvious of these factors are: experience, ingenuity, rationality, thoroughness, education, desire, and by no means least, an accumulation of events which puts a person into a position where he is required, by the nature of his responsibility, to exercise an unusual amount of control over project matters.

You will, I am sure, agree that these differing levels of contribution should be accompanied by differing levels of pay. And in this regard, most men will feel that they have been fairly treated if they know that their compensation is in keeping with national and regional standards, and that their own special attributes have been taken into account in arriving at the final salary. There are other differences. Men with supervisory responsibility need private offices, so that conversations of a confidential nature may be kept confidential. No person likes to receive a disciplinary action in full public view, nor is it practical to take a man into a conference room somewhere every time a confidential matter must be discussed.

And what of the effect upon the junior man just entering the organization, if he discovers that the company does not think enough of its engineering management to provide them with higher salaries, private offices, and other privileges? He probably will seek out a different company—one which will offer him what he is likely to term "growth opportunities."

This still leaves us with the basic question of just how we are to make concrete expression of the fact that the engineer is, indeed, a member of management. First, we must do all the obvious things, with this matter of a fair and proper salary at the head of the list. Then we must work to establish a "professional atmosphere," which includes such items as absence of time clocks; a minimum of regimentation; professional-society membership and attendance; encouragement to accept the maximum level of responsibility possible, so that an individual's horizons can be ever-expanding; and a continuing effort to keep engineering personnel informed concerning company activities and objectives. Not only this, but we must offer a mode of advancement to the technical man who may not be fitted for administrative work, or who may not desire it. Such a mode should offer equivalent salary and so-called "status symbols" as though the man had moved over into engineering administration. This parallel "technical ladder" obviously must cut off somewhere below the level of the president's salary.

This leads us to another means by which

continued on page 30

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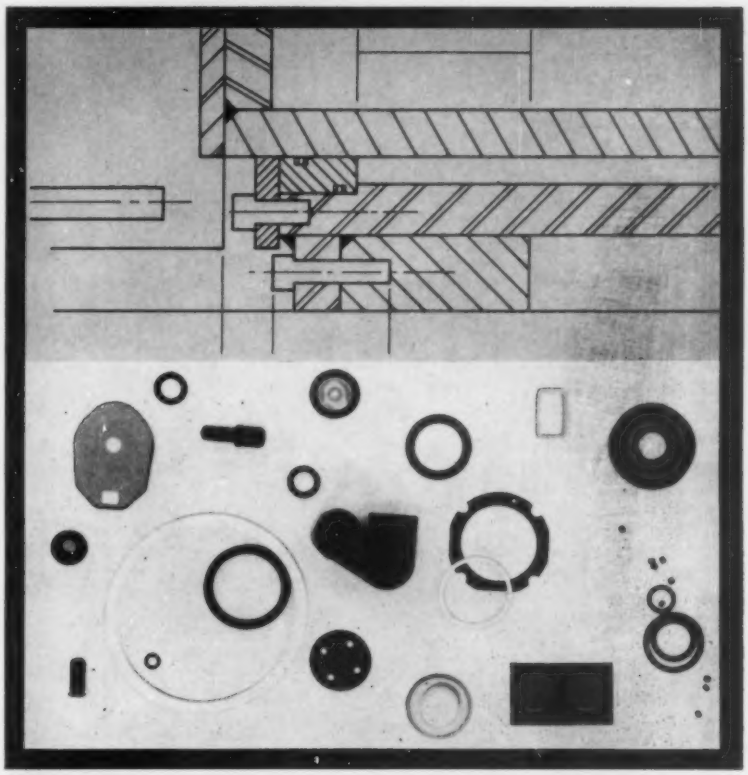

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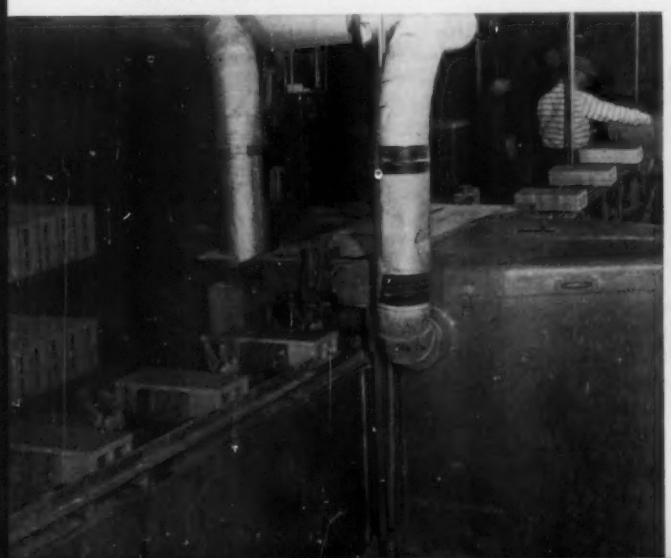
CIRCLE 27 ON READER SERVICE CARD

Tile being ground to a tolerance of 1/16" in an overall length of 15¾". Two grinding heads staggered in same machine grind two ends in same pass. Due to planned oscillation, belt here is shown in lowest position of the cycle of the up and down movement on roll.

Tile production line showing automatic grinding machine equipped with LORIG-ALIGNER self-centering rolls to keep grinding belts perfectly aligned.



LORIG-ALIGNER self-centering rolls have a toeing-in action from both sides that keeps belt centered. Type 1 rolls were used on the sander.

This mark tells you a product is made of modern, dependable Steel.

Tile production boosted over 100% with belt grinders using LORIG-ALIGNER self-centering rolls

The Arketex Ceramic Corporation, Brazil, Indiana, produces load-bearing architectural tiles to within 1/16" tolerance to the 15¾" overall length. Both ends are ground or sized *before* glazing and firing.

Mr. Ralph Weston, Vice President in charge of production, says, "Originally the production line required hand grinding and delivered 5 to 10 tiles a minute. This was too slow. Next, we installed two emery wheels facing each other across the production line. Output went up to 11 tiles per minute but this was still not enough to satisfy us. In our search for higher efficiency, we called in the Ryman Engineering Company of Pittsburgh, a licensee for LORIG-ALIGNER rolls. They recommended installing two belt grinding machines so that both ends of the tile could be ground automatically at the same time."

In designing the belt grinding machine, Ryman Engineering used LORIG-ALIGNER self-centering rolls to keep the belts in perfect alignment. Production jumped, labor costs were reduced. The savings are obvious.

As a matter of fact, belt alignment was so perfect after installation of the LORIG-ALIGNER rolls that it was possible to install an oscillating feature. In this way, the full grinding face of the belt could be utilized. Arketex was so pleased with the efficiency of this machine that they later so equipped two additional lines. Similar grinding equipment is now under study for other products.

LORIG-ALIGNER self-centering rolls with their built-in centering action also have hundreds of applications in industry where conveyor belts are used or where continuous sheets of material must be kept in positive alignment. Steel or rubber-covered rolls are both designed to supply this action. These are obtainable from licensees for LORIG-ALIGNER self-centering rolls whose names will be supplied on request. For more information, send the coupon.

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Tennessee Coal & Iron — Fairfield, Alabama
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United States Steel

Mr. Ralph H. Weston, Vice President in charge of production at Arketex, compares rough, unfinished tile (top) with stack of accurately ground tiles.

United States Steel
Room 6064, 525 William Penn Place
Pittsburgh 30, Pa.

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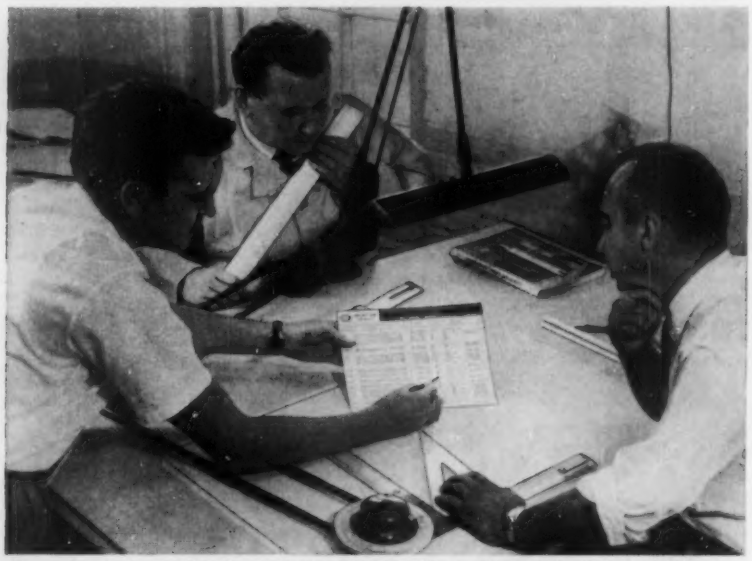

In a typical application of the POST Diazo Materials Selector Chart, a draftsman, supervisor and reproduction specialist solve a special print-making problem in short order.

Solve unusual reproduction problems with new Diazo Selector Chart

Keeping up with rapid developments in graphic reproduction and communication techniques is a difficult job these days, even for the experts.

From the engineer's and draftsman's point of view, it's largely a matter of sorting out the specific information which helps him do a better job.

The new Post Diazo Materials Selector Chart does just that—provides a condensed, tabular reference piece that helps you anticipate the ideal diazotype prints for various needs before they occur. This convenient chart gives brief information on sensitized papers, intermediates and specialties in terse "what, when, why and where" style.

If you're concerned, for instance, with print distribution to different departments, units or groups, then prints on a variety of colored stocks might be the answer.

Increasing print production from diazo equipment with a lower-power light source . . . making legible prints from worn old tracings . . . even making copies from an opaque print . . . all can be handled by use of new Post 206M-14, a fast, extra-sensitive whiteprint paper.

Suppose a design conference calls for a poster, actual size, made from a large engineering drawing, rigid enough for display, tough enough for extreme handling and on-the-spot sketches? Post diazo-sensitized cardstock in 32 or 50 lb. weight can turn the trick on standard reproduction equipment, ammonia process or semi-moist. For many more helpful solutions to similar situations, ask for your personal file-size copy, of the Post Selector Chart, available from your Post dealer or Frederick Post Company, 3642 North Avondale Avenue, Chicago 18, Illinois.

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READER TO EDITOR.....continued

we can make an engineer feel that he is identified with management, and that is to make public recognition of his contributions. However, it surely is apparent that such public recognition must be based upon something universally acknowledged as a major contribution, or else it loses its punch because of insufficient cause, or questionable motive. With regard to the cover picture in question, we felt that, by so honoring these individuals, we would be providing exactly the sort of public recognition we are talking about, and in effect would be letting the world know that here is a group of whom we are proud—proud because they worked hard, long, and effectively to accomplish a difficult task in commendable fashion. Every man in that group made direct, personal contributions to the final successful introduction of the Transflo calculator, and, furthermore, knows that his own work played an important and vital part in the total effort. The unfortunate thing, Mr Rogers and Mr Sheehan, is that what you have mistaken as a rigid portrayal of class distinctions, was in reality a photographer's desire to achieve photographic "balanced imbalance" and composition interest.

And this, gentlemen, brings me to the only real bone I have to pick with you. At the time of the taking of the photo, the shirtsleeves matter was the butt of several jokes, and I even recall the remark, "At least this way people will know who really did the work," and for the life of me I can't recall if the remark came from a "Chief" or an "Indian." At any rate, the whole thing was passed off lightly, and as of no consequence. But now, with every man in that photo reading your letter, the whole thing, suddenly and unnecessarily, assumes an unpleasant aspect, and may make some readers wonder if there isn't something there that requires worrying about.

Thus it is that I feel compelled to reply to your characterization of us as a class-conscious, schism-ridden group of status-seekers. I would not want any member of my staff to think that, by my failure to answer your allegation, I was silently acknowledging its truth. I do not mind personally being made the butt of a joke, since I have as good a sense of humor as the next man, and possibly better than most. But I do feel that I must object to the inference, directed at my associates, that I might regard them as second-class citizens. Such a thing would be the complete reverse of all the ideals we have striven toward here at Marchant.

Nevertheless, I wish to thank you for a few moments of good-natured laughter, and most especially for the very fundamental and serious point of view you presented. I hope you may find in the above paragraphs some seeds of thought as to how these ideals might be further expressed, to the mutual benefit of all.

—John D Kemper
Vice-president—Engineering
Marchant Div of
Smith-Corona Marchant Inc

• Our editorial, p 51, further discusses this subject—Ed.

Reviewing a Review

To the Editor:

The review of my book *The Story of Engineering*, (Doubleday-Anchor) in your July 25th issue, p 52, has just come to my attention. In spite of the fact that it was clearly stated in the preface that this story was covered only "in outline-survey form" and that (even in a book of 528 pages) this involved "a major problem of selection and condensation" and "the omission of many details of interest to the engineer," your reviewer appears to feel that "the chief drawback" to the work is lack of depth. I agree that it could be easily expanded not only into several volumes, as he suggests, but into a five-foot shelf of books. Such a "library," however, would be excessive in cost, defeating the major aim of the work, namely the production of an inexpensive review and summary of the rise and development of the engineering profession.

Your reviewer remarks, "The term engineer is relatively new (in the old days they were called mechanics)." If he will turn to page 82 he will note that the title "engineer" has been in use for close to a thousand years and that the name engine had originated some seven or eight centuries earlier. I know of no use of the alternate title he suggests ("mechanics") except in Greece. "In the old days" the professions we know today as architecture and civil engineering were one, and the titles used were *architekton, architectus* or *architect*—namely, *chief-technician*.

—James K Finch
NYC

COMING EVENTS

OCTOBER

16-21 . . . Society of Motion Picture and Television Engineers, International Congress on High-speed Photography, Sheraton-Park Hotel, Washington

17-19 . . . American Society of Lubrication Engineers jointly with ASME, 7th Annual Lubrication Conf, Statler-Hilton Hotel, Boston

17-21 . . . American Society for Metals, National Metal Exposition & Congress, Trade & Convention Center, Philadelphia

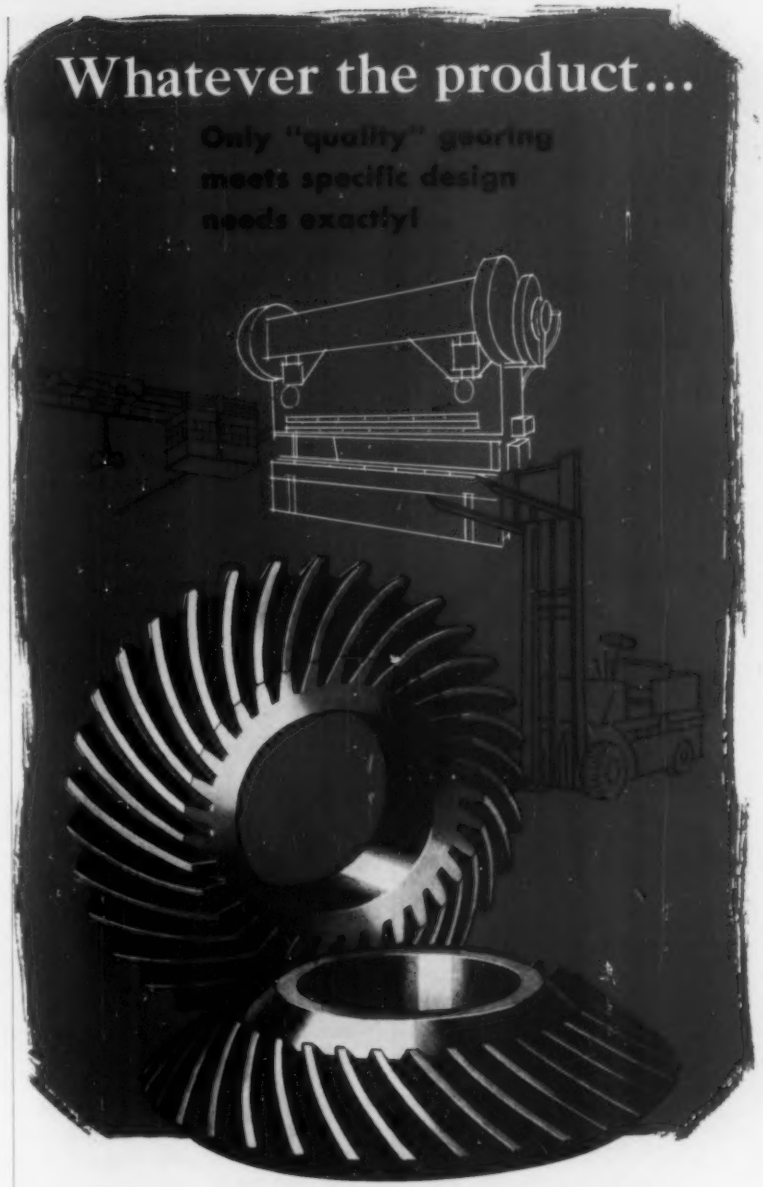
19-21 . . . Society for Experimental Stress Analysis, Mechanisms in the Nuclear Age, Univ of Calif, Berkeley

20-21 . . . Armour Research Foundation, National Conf on Industrial Hydraulics, Hotel Sherman, Chicago

23-26 . . . American Gear Manufacturers Assn, Annual Meeting, Edgewater Beach Hotel, Chicago

25-27 . . . SAE, National Transportation Meeting, Hotel Leamington, Minneapolis

27-28 . . . American Society of Industrial Designers, Annual Conference, Edgewater Beach Hotel, Chicago



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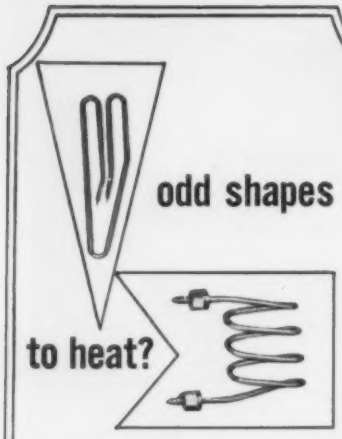

use

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Vulcan Tubular Heaters can be formed into an endless variety of unusual shapes to provide a lot of heat in a little space. They are easily cast into aluminum or other metals. They are ideal for immersion in liquids, soft metals or molten salts. Straight tubular heaters are readily clamped to metal surfaces or inserted in machined grooves. And they can be furnished with flattened surface for even more effective heat transfer.

Vulcan Tubular Heaters are available in a wide choice of lengths — 10″ to 185″ (special, shorter or longer); diameters — .250″; .280″; .333″; .450″; .496″; .540″; wattage — 10 to 10,000 (or higher); voltage — standard 120, 240 or 480; special 6 to 600 (or higher); sheaths — copper, steel, aluminum, high temperature alloys.

Write for catalog and prices.

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Versatility in Electric Heating

VULCAN ELECTRIC COMPANY, Danvers, Mass.

WHY DON'T THEY R&D..?

The following problems have been extracted from a list compiled by the Army Medical Service and recently published under the direction of the Chief of Army Research and Development. "Problems Guide, Vol III Medical Service," is one of a series of 8 such publications devoted to problems encountered by each of the Army's branches. Industry requests for copies of the Guides must include proof of security clearance (where necessary) and a statement of the company's research capability. Proposed solutions to the following problems should be addressed to Commanding General, US Army Medical Research and Development Command, Main Navy Building, Washington 25, DC.

. . . a compact folding microscope with built-in light for use in medical field installations. It should be suitable for examining blood smears (for diagnosis of malaria), blood counts and routine laboratory diagnostic work, and should be packaged in a compact, waterproof container.

. . . a constant-temperature, multipurpose container for medical supplies. Medical units operating in forward areas have an urgent need for a container that can be used either as a refrigerator, a blood-storage facility, or an incubator for bacteriological or serological tests. It should be light, well insulated, and powered by a self-contained source that will operate the unit for prolonged periods without recharging.

. . . a long-range, casualty marker that will direct medical aid men to injured personnel. A significant number of wounded men could be saved if found soon enough to evacuate them to medical service facilities. The problem is particularly acute in jungle and arctic warfare and in all night-time operations. There is an urgent need for a small, lightweight casualty marker with a range up to 300 yards. Range must be adjustable so that the marker can be set to radiate only far enough to reach the man's own line but not far enough to notify the enemy of the extent and distribution of casualties.

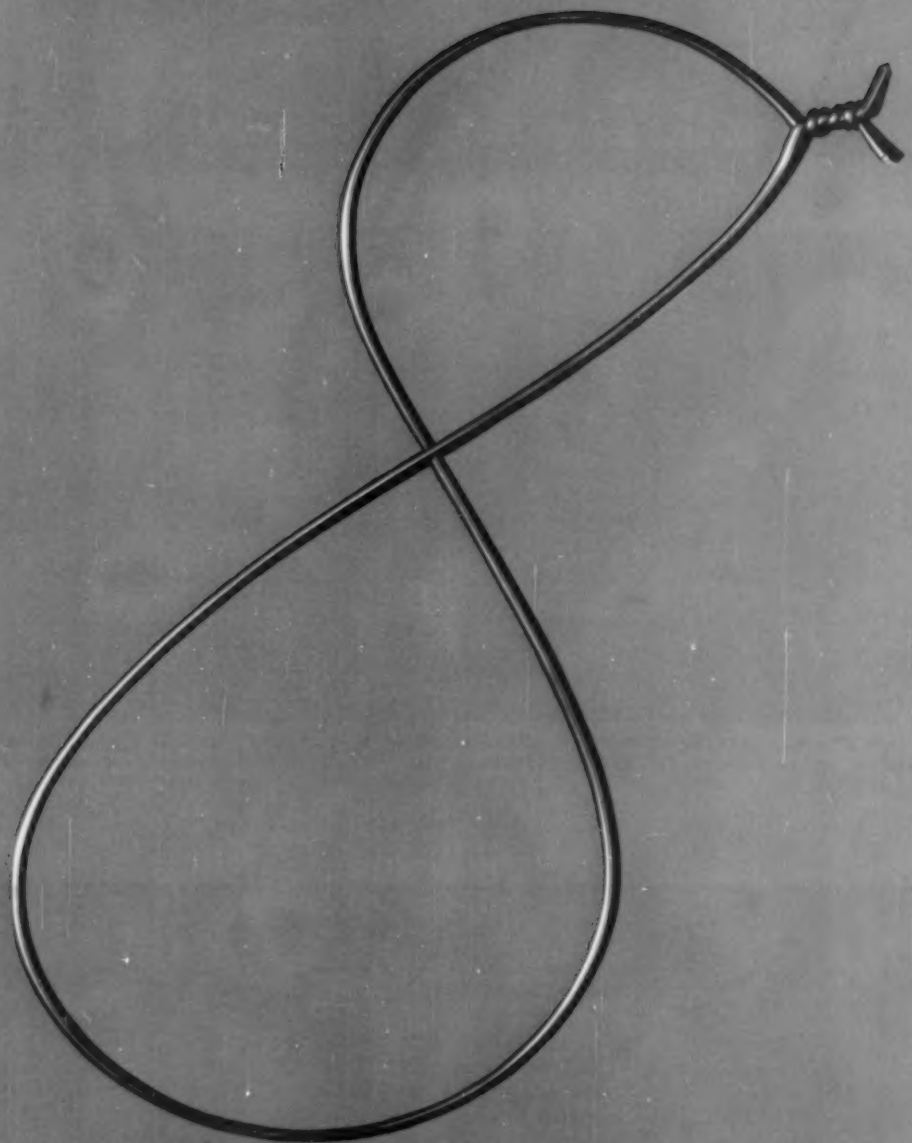
. . . a self-propelled litter—capable of carrying a patient at walking speed and with sufficient power to climb slopes up to 30° under the guidance of one attendant. The propelling mechanism must be silent or muffled to the extent that location of casualties is not disclosed by motor noise.

. . . a spray-on material suitable for temporary external splints. A quick-setting plastic material that could be sprayed from an aerosol container could be used to immobilize fractures in the field prior to evacuation by litter carrier or field ambulance. A similar product might also be used as a semipermanent splint or cast.

. . . a field-hospital bed that can be transported compactly, set up quickly and discarded after use. It has been suggested that a serviceable bed might be made from a semirigid plastic foam molded on the spot in a collapsible mold. Such a bed would be light, durable, and have a surface soft enough to serve as a mattress. The foam must be impervious to blood and other body fluids but so cheap that the bed could be abandoned or destroyed when the medical unit was displaced.

Have you a problem, based on known scientific principles, which seems to have an answer somewhere within the limits of present technology? To inspire inventors along worthwhile paths, PRODUCT ENGINEERING invites you to trade such problems with fellow readers who have a fresh viewpoint or more time to experiment. We pay $10 for each one accepted.

CIRCLE 33 ON READER SERVICE CARD→

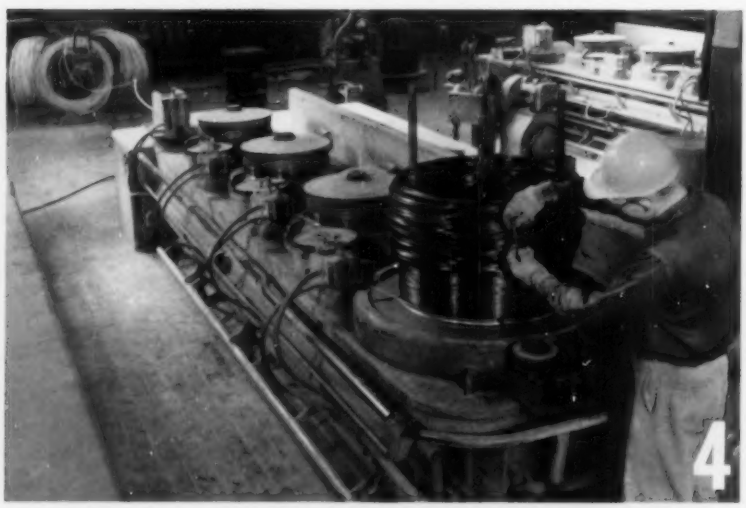


good reasons
why it pays to specify
American Steel & Wire
for all of your
stainless steel wire needs

8 good reasons why it pays to specify American Steel

By using modern welding techniques, we can turn out continuous coil weights as heavy as 500 pounds to suit your particular needs. Heavier coil weights reduce down time on your machines, speed handling of material.

The latest in controlled annealing methods enable us to produce uniform properties in stainless wire that assure consistent performance on your equipment and in your product.



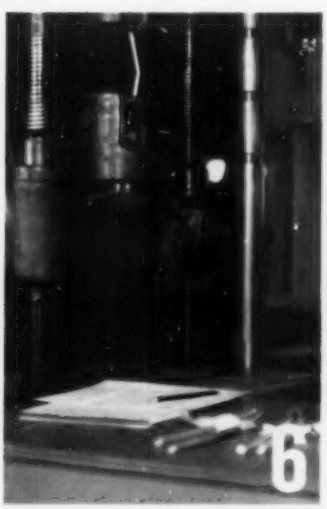
To insure the gage of your stainless is consistent from end to end, it's checked constantly during the continuous drawing process. ASW's wide range of modern, precision drawing machines can turn out everything you need in type, size and finish.

After drawing, the wire is again inspected to make certain that the gage and finish are exactly as specified.

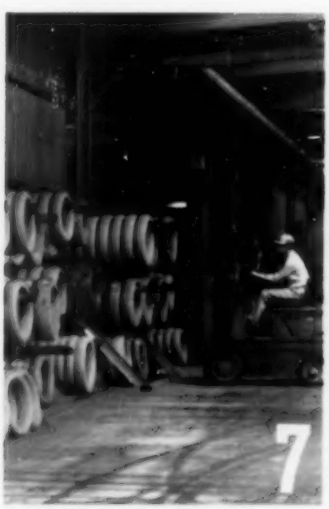
This mark tells you a product is made of modern, dependable Steel.

& Wire for all of your stainless steel wire needs

Up-to-date salt and acid bath techniques and equipment guarantee the smooth, clean wire surface so important to the finished quality of your product. After cleaning, coatings such as this electrolytic copper coating are often applied to make your job of fabrication easier.



During processing and at finished size, our stainless wire is tested for tensile strength and other properties to make sure it meets specifications. Such tight control insures quality.

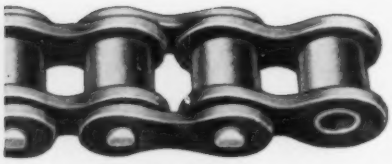


To insure supply and fast delivery, we stock 300 to 400 tons of cold heading stainless wire in addition to a heavy tonnage of other stainless steel wire items at all times.

8 **Our stainless steel wire service is second to none.** In addition to our regular salesmen, we have special Stainless Steel representatives in your area who have both engineering and mill backgrounds. They know metals, they know production. Their assistance can be invaluable to you in solving the really tough ones. Call your nearest ASW Sales Office today. If you like, we'll have a man out to see you at your convenience. Or if you prefer, write American Steel & Wire, Dept. 0387, 614 Superior Avenue, N.W., Cleveland 13, Ohio.

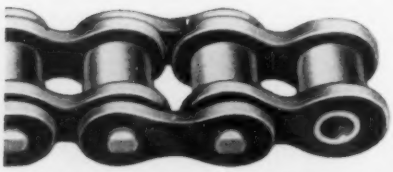
American Steel & Wire Division of United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors
United States Steel Export Company, New York

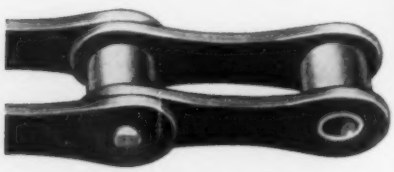


SINGLE STRAND

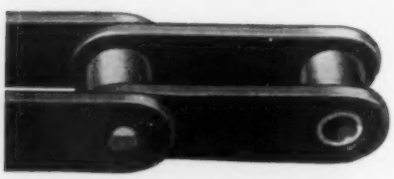
DOUBLE STRAND



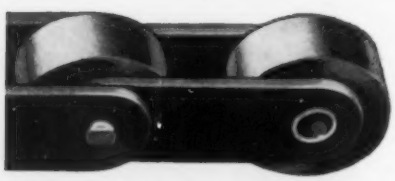
SINGLE STRAND, HEAVY SERIES



DOUBLE PITCH TRANSMISSION

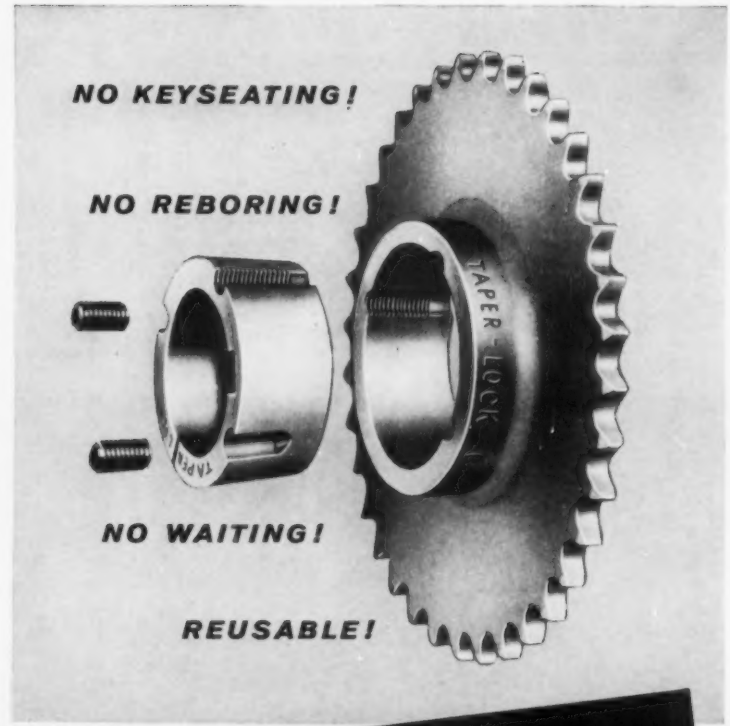


DOUBLE PITCH CONVEYOR



DOUBLE PITCH CONVEYOR, LARGE ROLLERS

CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look under "Dodge Transmissioneer" in the *white* pages of your telephone directory, or in the yellow pages under "Power Transmission Machinery."



TAPER-LOCK SPROCKETS DODGE ROLLER CHAIN

DODGE Quality Roller Chain, teamed with Dodge Taper-Lock Sprockets, results in chain drives and chain conveyors that have the precision, efficiency and stamina necessary for the real economy of *long life*.

Moreover, Taper-Lock's reusable bushing makes a difference in overall cost. The ease of Taper-Lock mounting, the elimination of reboring, keyseating, and wasted time, add to the saving. Precision machining and true articulation lengthen the life of *both* sprocket and chain.

The Dodge line of chain, including standard attachments, is extensive. It meets a high percentage of all chain requirements.

In the Double Pitch series (both Transmission and Conveyor) the sizes which require special spacing for perfect tooth action are offered from stock in special double pitch design — to double the life of the chain and the sprocket!

Ask your local Dodge Distributor. Or write us for bulletin.

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DODGE
of Mishawaka, Ind.

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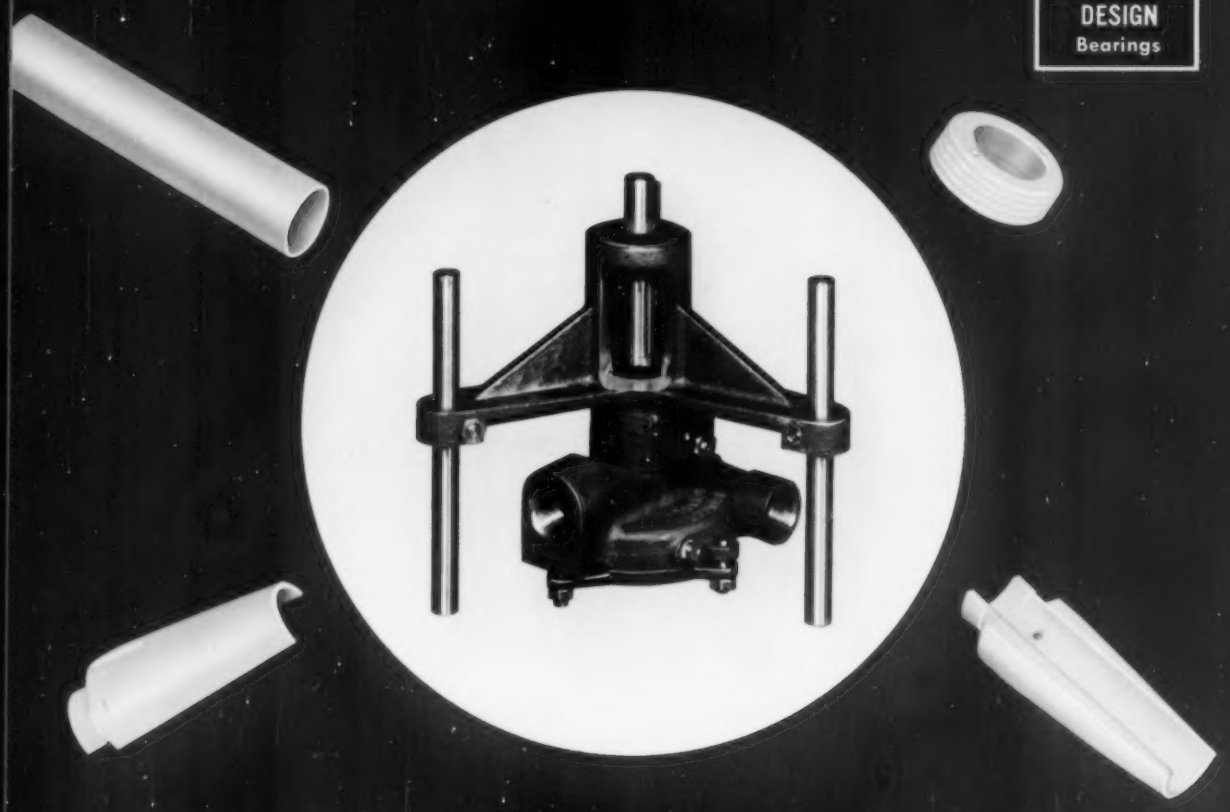
DU PONT

ENGINEERING FACTS ABOUT

TEFLON®

FLUOROCARBON RESINS

NUMBER M-10
IN A SERIES
MECHANICAL
DESIGN
Bearings



Pump bearings of TEFLON®... submerged in nitric acid... work where lubrication is impossible

Design engineer's problem: Given—a vertical centrifugal pump, to operate in a nitric acid environment, at 3,450 rpm; conventional lubrication impossible because of contamination problems. *To find*—a bearing material, self-lubricating, to function under corrosive conditions for long periods of time.

Solution: Pump bearings machined from pure, non-porous stock shapes of Du Pont TEFLON TFE-fluorocarbon resins. The exceptionally low coefficient of friction of TEFLON makes lubrication unnecessary. And TEFLON resins are completely inert to virtually all chemicals, including nitric acid. In the centrifugal pump shown above, the two halves of the bearing are designed to open up at increasing speeds, providing free-floating bearing action.

This is an example of the utility of bearings of TEFLON resins under circumstances where no other bearing material could work satisfactorily. But even where conditions are less exacting, the use of TEFLON resins in bearings insures longer service life, fewer maintenance and downtime problems . . . and eliminates the need for lubrication. On the following page you will find basic data on the performance characteristics of bearings of TEFLON and the ways in which they make possible cost-saving design improvements.

OVER

TEFLON *is Du Pont's registered trademark for its family of fluorocarbon resins, including TFE (tetrafluoroethylene) resins and FEP (fluorinated ethylene propylene) resin.*

How bearings of TEFLON® help you solve design problems

FIGURE 1

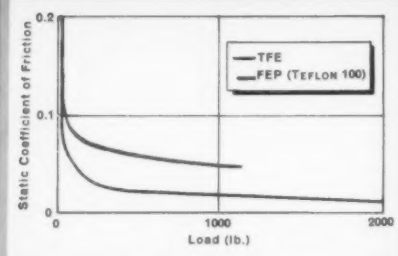


FIGURE 2

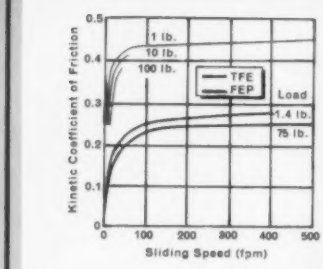


TABLE 1

UPPER SERVICE LIMITS OF VARIOUS CONSTRUCTIONS

Material	Load (psi) ≤ 2 ft. per minute velocity	Velocity (ft./min.) 100 psi load
Unmodified TFE resins	500	25
Compounded TFE resins	2,500	200
Reinforced TFE resins	40,000	1,000
Fabric of oriented fibers of a TFE resin	60,000	60

TABLE 2

Shaft Diameter (inches)	Clearance (inches)
¼	.003-.004
½	.004-.005
1	.004-.006
2	.008-.010

Properties of bearings of TEFLON

TEFLON fluorocarbon resins have properties which make them excellent materials for journal and plane-surface bearings. Filled compositions and reinforced constructions are usually used to tailor bearings of TEFLON for increased loads and velocities or high wear resistance. Among the major benefits that TEFLON resins offer as bearing materials are:

1. Low coefficient of friction—The static coefficient of friction of TEFLON resins is even lower than the dynamic value. At high loads and low velocities, TEFLON resins have a lower friction than any other solid material . . . significantly lower than lubricated metal bearings. (See Figure 1 for static coefficients of friction of both TEFLON TFE resins and the new, melt-processible TEFLON FEP resin. The kinetic coefficients of friction vs. sliding speed at 73°F. are shown in Figure 2.)

2. Temperature resistance—Bearings of TEFLON TFE resins have exceptional thermal stability and are suitable for continuous service up to 500°F. At -450°F. these resins show the same friction that would be expected for similar conditions of load and velocity at room temperature.

3. Chemical resistance—Bearings of TEFLON resins are completely resistant to virtually all chemicals and solvents. They have no moisture absorption and are completely unaffected by outdoor exposure to weather.

4. Other properties—Bearings of TEFLON resins are tough, abrasion resistant, and have the ability to embed hard foreign contaminates.

WHERE TO USE

Bearings made of TEFLON resins are being used where lubricated bearings are undesirable or incapable of operation, in extreme temperatures or corrosive conditions, or where there is a possibility of lubricant failure. They are used where safety and reliability are essential. They are used near substances that must not be contaminated; with non-lubricating liquids such as gasoline; with corrosive substances; at low or high temperatures where common lubricants are useless; under extreme conditions of humidity; in areas where there is danger of fretting or galling; where stick-slip motion is undesirable; where space or weight savings are essential.

DESIGN CONSIDERATIONS

Service Limits

Unfilled TEFLON resins are used in light load, low PV factor bearings. For higher loads and speeds, bearings of reinforced constructions and filled compositions of TEFLON resins provide the increased compressive strength, thermal and dimensional stability, and wear resistance required. See Table 1 for indications of the capabilities of various types of bearings of TEFLON TFE resins.

Bearing Clearances

The effect of clearances on wear and noise is not as critical for bearings of TEFLON as for bearings of metal because of the resiliency of TEFLON resins and their ability to conform to the geometry of the holder. The thickness of the TEFLON, type of filler or reinforcing and the bearing construction used often determine the clearance required. See Table 2 for examples of successful clearances in bearings of TEFLON.

Surface Finishes

The surface finish obtained by molding TEFLON resins is ordinarily adequate for bearing use. If the bearing is machined, a finish of 35 to 40 micro inches (RMS) has tested satisfactorily. Although the finish of the shaft or mating member is less critical than with metal bearings, a shaft finish of 14 to 16 micro inches is preferred for very low wear.

FOR MORE INFORMATION about the properties and uses of bearings of TEFLON and the new fact-filled booklet "Designing with TEFLON", write to: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department T-36-10, Room 2526, Nemours Building, Wilmington 98, Delaware.

In Canada: Du Pont of Canada Limited, P.O. Box 660, Montreal, Quebec.

DU PONT
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TEFLON®
FLUOROCARBON RESINS

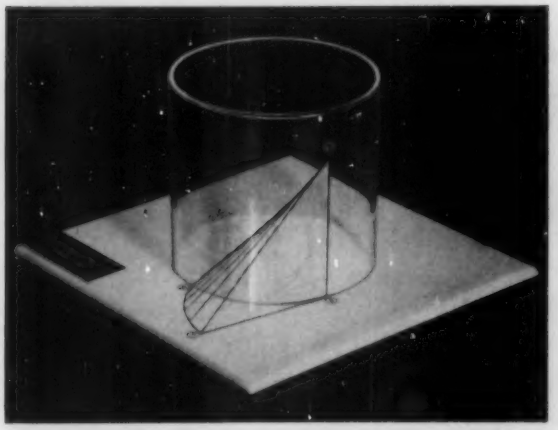
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

WORM GEARING

Why the INVOLUTE HELICOID thread form?

Introduction of involute helicoid worms by Delroyd marks the first time extensive use of this design has occurred in America. Therefore the question arises: "What is the involute helicoid worm and what are its advantages?"

Basically an involute helicoid worm is the same as an involute helical gear. However, this similarity is not easily recognized because of the difference in angle of thread or



tooth helixes in the two types. Regardless of the difference in helix angles, both types have an involute thread or tooth profile in the transverse plane, i.e., a plane perpendicular to the axis.

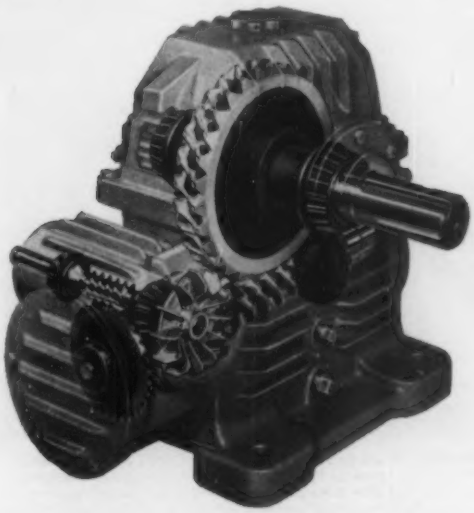
The thread surface is made up of a series of involute curves lying in transverse planes. The thread flank generating edge is a straight line tracing out a helical path (see illustration). Manufacturing *simplicity* of generating and checking to straight line form control provides consistent production of worm and generating hobs of high *accuracy*. Deviation from the straight line in checking *hundreds* of worms in one production lot can be held to within a few *ten* thousandths of an inch.

The easy and accurate attainment of *exact similarity* between worm and hob provides complete compatibility of worm to gear without manufacturing process interruptions to modify and change hob form. Form does not change as hobs are sharpened. Accurate interchangeability is an undisputed fact.

Only the involute helicoid worm form permits practical application of calculable compensating features for gear deflection under load. All gears have leaving side contact with entering side gap to form beneficial oil wedge. Kinematically accurate tooth meshing avoids the acceleration and deceleration inevitable with other forms.

Superior performance is the result, since this form outperforms all others. Size for size, the DELROYD involute helicoid worm form offers a higher selection safety factor with no premium cost.

For further information on DELROYD worm gearing, write on your company letterhead for our new 84-page catalog, the most comprehensive in the industry.



DE LAVAL STEAM TURBINE COMPANY

801 NOTTINGHAM WAY, TRENTON 2, N. J.

DL-201

General Plate Clad Metals

1. Clad Contact Rivets and Buttons—Proctor-Silex Corporation engineers found that General Plate Contacts carried a unique warranty that was only possible because of General Plate's quality control of the entire manufacturing process — melting, rolling, fabrication. Certified AQL inspection reports are available with shipments.

2. Truflex® Thermostat Metal—General Plate Truflex Thermostat Metal is supplied in strip form which Proctor-Silex Corporation blanks and forms into the main bimetal element and compensating member.

Truflex Thermostat Metal is available in cut-to-length strips or long continuous coils to meet your needs. Truflex is also furnished in formed elements or completed assemblies to meet the most exacting parts specifications.

FREE: Write for your free Truflex Nomograph Calculator for plotting first sample size determinations.

Team Up to Cut Costs...

AND IMPROVE PERFORMANCE FOR **PROCTOR-SILEX CORPORATION** IN THEIR VARITHERM* INFINITE CONTROLLER

1 *Silver Clad Electrical Contacts*

2 *Truflex Thermostatic Bimetal*

3 *Clad High Conductivity Spring Metal*

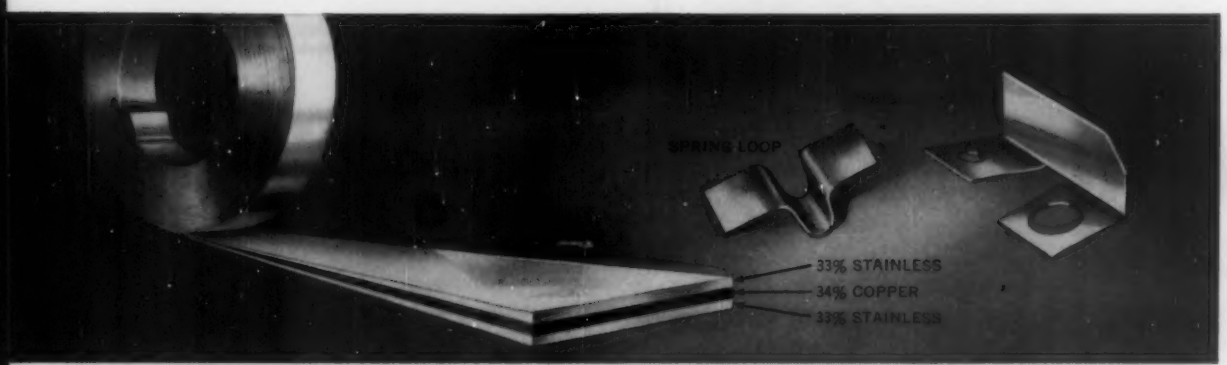
The new, unique Proctor Varitherm provides unlimited heat settings that are uniform over the entire heating element. Eliminating rheostats and transformers, it works on an *on-off system* to maintain constant heat at any setting.

Three different General Plate Products are used, as illustrated. They were selected, first because clad metals are required in order to produce desired *combinations* of *characteristics*, and, second, because we recommended and can produce special *combinations* of *metals* that materially improved the performance of this remarkable new controller.

These three General Plate Products team up to *reduce labor costs* by eliminating a time consuming assembly step and *to improve performance* by doing away with an embrittlement that was encountered during the development and testing period.

Users of General Plate Products benefit from our unique ability to design and manufacture clad metals for their specific needs. Complete technical literature and samples of all our products will be sent to you. Competent field engineers are available to review your old or new designs with you and provide design assistance. Write for Catalog GP-1B.

*Reg. T.M. of Proctor-Silex Corp.



3. Clad High Conductivity Spring Metal — The original torsion member was made of two-piece construction. Using General Plate stainless steel clad copper, reliable spring characteristics and high conductivity are now obtained in a single piece which is easily welded to the stainless case.

TEXAS INSTRUMENTS
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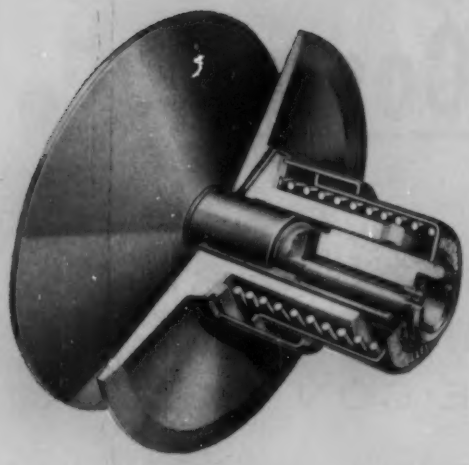
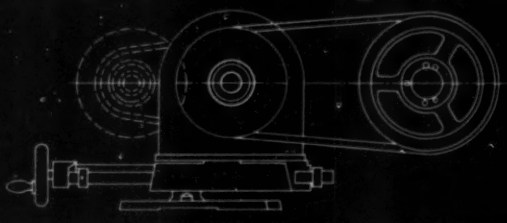
METALS & CONTROLS DIVISION
1010 FOREST STREET · ATTLEBORO, MASS.

GENERAL PLATE PRODUCTS: Clad Metals • Electrical Contacts • Truflex® Thermostat Metal
Gold, Silver, Platinum and other Precious Metal Products

GPG-22A

CIRCLE 42 ON READER SERVICE CARD→





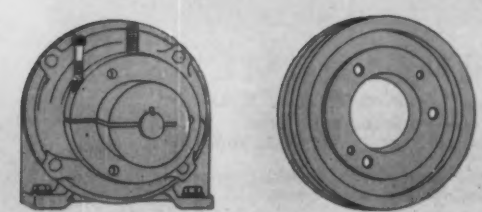
PROBLEM: Need 15 hp and up to 3:1 continuous speed variation with equipment running.

SOLUTION: For horsepowers from ½ to 15, use Worthington Motor Pulley drive with Anglematic motor base. The Anglematic motor base allows continuous speed control while maintaining belt alignment. It keeps the motor pulley design simple, trouble-free; two-piece companion sheaves have separate hubs and the 2 "Golden Screws" for easier, more dependable installation.

PROBLEM: Need less than 2:1 speed variation on 500 hp installation, with equipment running.

SOLUTION: Use the motion control Multi-Pitch sheaves. For fixed center drives and maximum variation, use a double motion control drive arrangement. For applications not requiring speed changes with equipment running, choose the less expensive stationary control Multi-Pitch sheave.

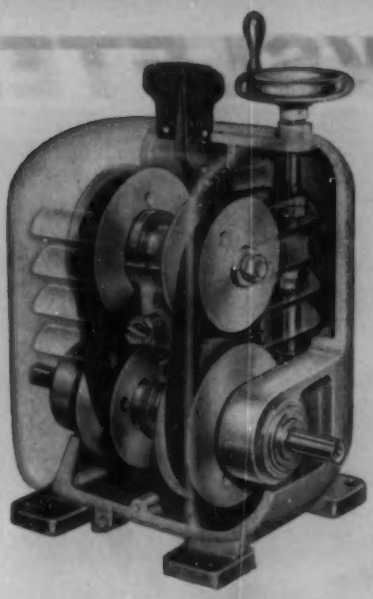
VARIABLE SPEED PROBLEMS

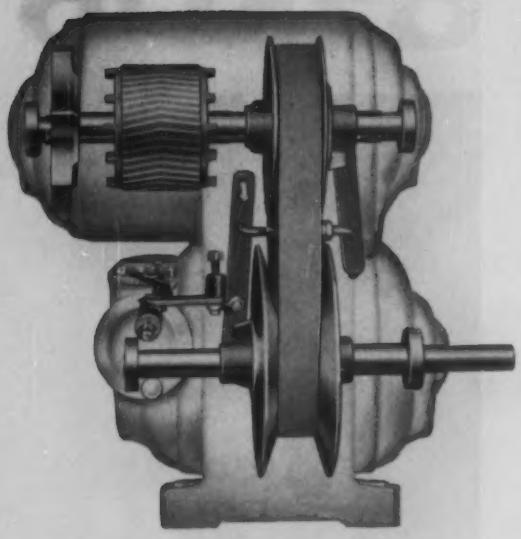


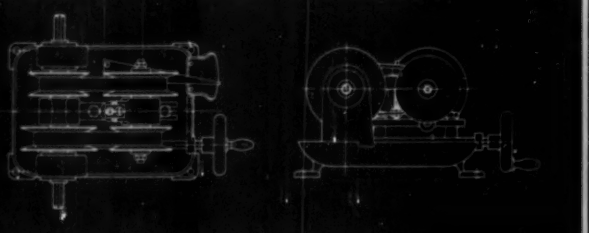
You need, of course, just one right answer to any variable speed problem. But if your answer is based on a choice from four stock Worthington variable-speed drive types and their hundreds of standard variations, chances are your final solution will be the best one. Certainly, you'll get compact design, accurate speed control and long

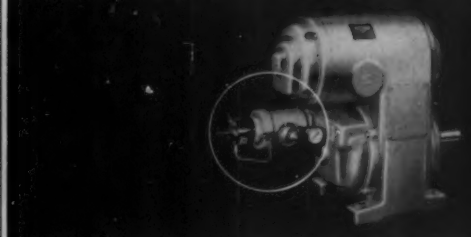
Motor Pulley and Multi-Pitch Sheave drives require companion sheaves. Both types of Worthington companion sheaves are equipped with the famous QD hub with the "Golden Screws" for permanent alignment and prevention of key drift. For longest belt life, select Worthington-Goodyear belts.

←









PROBLEM: Need 150 to 3000 rpm stepless speed variation while equipment is running.

SOLUTION: Use Worthington Allspeed Drive that can give up to 20:1 speed variation without stopping equipment. Compact design has straight through shaft for very simple installations with direct or other couplings. A skeleton frame or enclosed frame, in horizontal or upright types make installation even more easy and compact and any frame can be at any angle.

PROBLEM: Need automatically controlled speed variation as high as 10:1 in continuous process.

SOLUTION: Use sensing or monitoring device that converts production variations such as pressure, temperature, time, speed or liquid levels—to pneumatic pressures. Connect it to Worthington Variable Speed Motor drive equipped with pneumatic cylinder that actuates speed variation in direct proportion o any change in input signal. Electric, lever and remote hand controls also available. Horsepowers from ½ to 25.

...FOUR STOCK ANSWERS

equipment life—all at a very competitive cost for the job you want done.

To help you, Worthington variable speed drive catalogs contain complete "how-to-figure-it" engineering information, as well as product information. You can get them from your nearest Worthington representative or distributor listed in the Yellow Pages. Or use the coupon at the right.

WORTHINGTON

WORTHINGTON CORPORATION
Section 79-31, Oil City, Pa.

Please send me your new catalogs on the following variable speed drive components:

- ☐ Multi-pitch Sheaves
- ☐ Motor Pulley Drives (1 to 15 hp)
- ☐ Motor Pulley Drives (Fractional hp)
- ☐ Motor Drives
- ☐ Allspeed Drives
- ☐ Variable Speed V-Belts

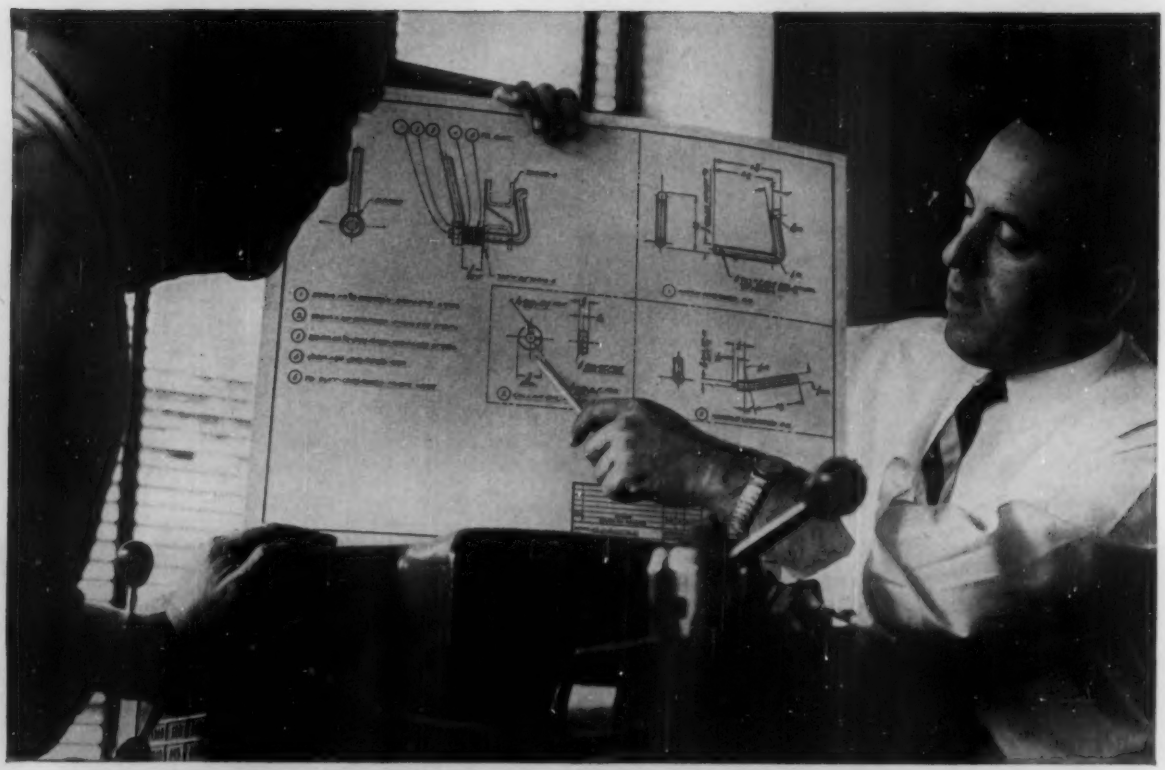
NAME_____

COMPANY_____

ADDRESS_____

CITY AND STATE_____

OZALID *NEWSLETTER*



Newest black-line intermediate paper copies fine details ... gives fast, easy-to-read prints

This paper's so new—and so hot—we're still getting plaudits from companies that field-tested it for us. (Top names in Engineering, Chemicals, Electronics, Petroleum, Metals, Retailing, Publishing.)

They found that Ozalid's new black-line 102 ITF picks up fine details, even from faint pencil-line drawings. And its opaque black line gives far more covering power than *any* comparable intermediate paper, sepia or black—*with no letup in speed.*

Why black line? A rich image that's a cinch to read, a snap to mass-copy. But that's not all.

The paper has a vellum base—100% rag, for durability and strength. It knows how to handle penciled, penned or typed additions. Also image corrections.

In addition, the base is transparentized—gives fast reprints even with age or constant use. And there's *no* transference, no damage when you file it with other papers, including Van Dykes and photographic material.

What machines accommodate 102 ITF? Any Ozalid machine with a Teflon screen or stainless steel mesh belt developer section. Or any other machine similarly equipped.

Here are some of the ways you'll benefit from 102 ITF:

You'll prevent damage to valuable original drawings by making fast mass-copies. Make changes without touching your original drawing. Distribute 102 ITF intermediates to branch plants, so they can make prints as needed. Save time in mass printing by using several duplicate originals. Superimpose one drawing on another, and print the composite on 102 ITF.

Chances are you've already thought of a dozen more uses for 102 ITF . . . or will, as soon as you start working with it. We'll appreciate it mightily if you'll shoot 'em along to us!

Top-quality, low-cost plastic-coated copy papers

Also from Ozalid—two superior copy papers. *Black* image paper, standard speed, for office use. And *blue* image paper, rapid speed, for engineering drawings.

Both are smooth-surfaced, semi-glossy. Both make crisp prints and copies. The black image paper (105 SZ) reproduces halftones from a film positive with photographic clarity. The blue image paper (208 SZ) is tough enough for shop and field use, and wipes clean with a damp cloth.

Both papers belong in your setup.

For more information, or a demonstration, get in touch with your nearest Ozalid man. His job is to help you do your job even better.

OZALID *Johnson City, N. Y. A Division of General Aniline & Film Corp. In Canada: Hughes-Owens Co., Ltd., Montreal*

DOT® NYLON PUSH-IN NUT

- Non-corroding
- Electrical insulator
- High pull-out resistance
- Straight legs won't distort thin, soft materials

This versatile fastening device snaps into place under finger pressure alone. Its straight legs permit easy insertion in square, punched holes while the tapered screw hole forces the legs apart when screw is inserted and ensures maximum pull-out resistance. Burrs do not impede the nut or prevent proper seating.

Ideal for use in virtually any type of thin-walled structure of sheet metal or plastic, the DOT Push-in Nut does not chip enamel surfaces, locks tightly without distorting the edges of the hole, resists vibration and serves as an excellent electrical and thermal insulator.

Suitable for use with #8 or #10 screws... locks in holes from .275″ to .292″ square... application thickness range: .030″ to .060″. Spacer type available with ½″ dia. head from ⅛″ to 1 1/32″ length in increments of 3/32″. Other types available in various sizes, round or square-headed, from 1/32″ to ⅛″ thick.

Engineering details and price information available on request.

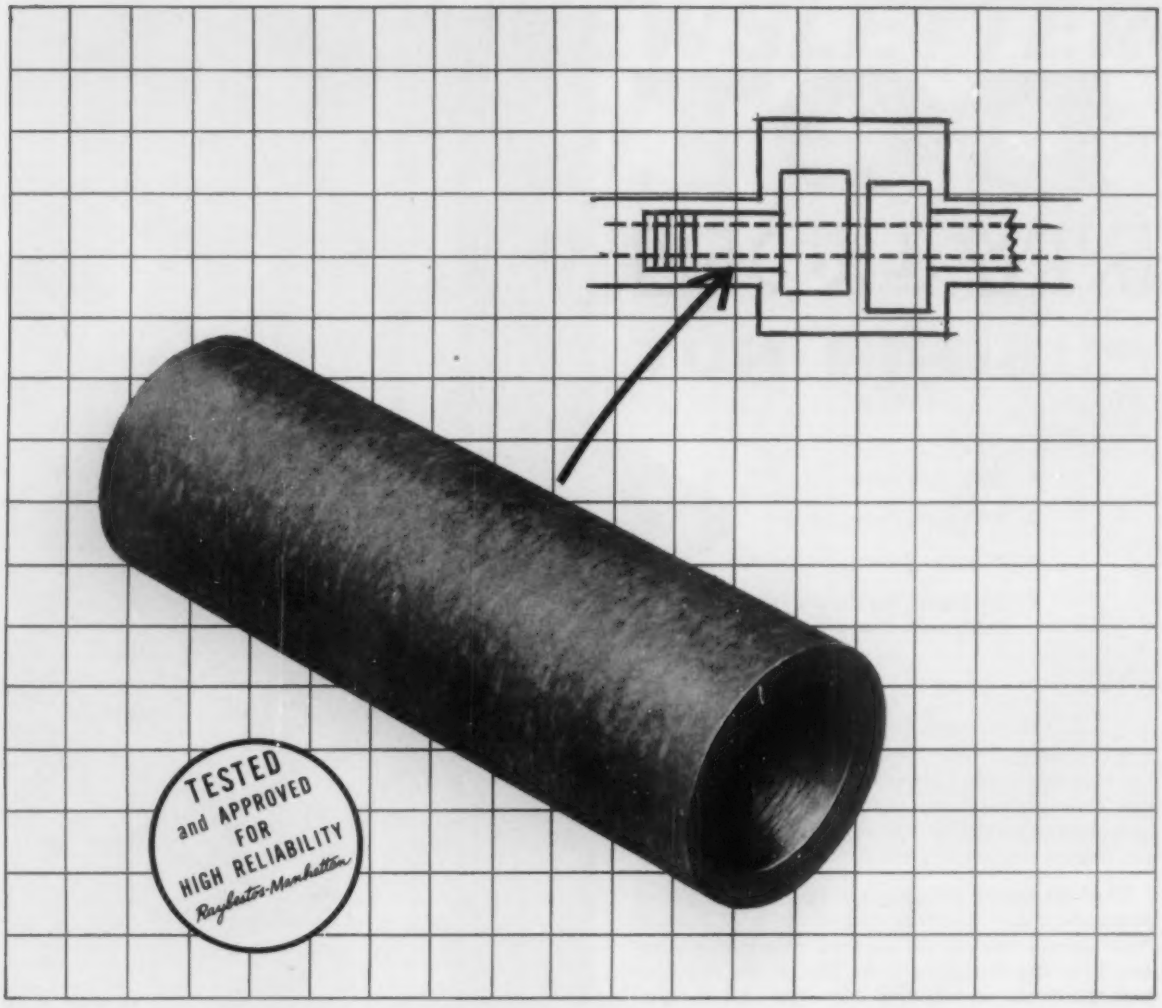
CARR FASTENER COMPANY

Division of UNITED-CARR FASTENER CORPORATION

Cambridge 42, Mass.

MAKERS OF DOT® FASTENERS

Offices in: Atlanta, Boston, Chicago, Cleveland, Dallas, Detroit, Kalamazoo, Los Angeles, Louisville, New York, Philadelphia, Syracuse



R/M CAPABILITY *produces*

reinforced Teflon bearing materials*

• to lower friction • to resist extrusion • to resist corrosion • to eliminate contaminating lubricants

R/M reinforced Teflon bearing materials are giving excellent service in a wide variety of industries. In the chemical industry, their use has greatly extended the range of chemicals that can be handled by a single pump. In the textile and food industries, they have eliminated the need for lubricants and the resulting contamination of materials in process. And in almost every application, they have lowered replacement costs and maintenance requirements while reducing wear.

Some R/M reinforced Teflon bearing materials can be machined to very close tolerances. Others, like R/M RL-742 asbestos-reinforced Teflon bearing material, can be molded to fit your specific requirements. The high rate of thermal expansion and poor flow characteristics of pure Teflon have been greatly reduced with this reinforced material.

If you have a bearing application, particularly where corrosion and high temperatures present a problem, or where normal lubricants cannot be used, R/M reinforced Teflon bearing materials may be the answer. Send data on your application.

*Registered trademark for Du Pont fluorocarbon resins

R/M PACKINGS
RAYBESTOS-MANHATTAN, INC.
PACKING DIVISION, PASSAIC, N. J.
MECHANICAL PACKINGS AND GASKET MATERIALS

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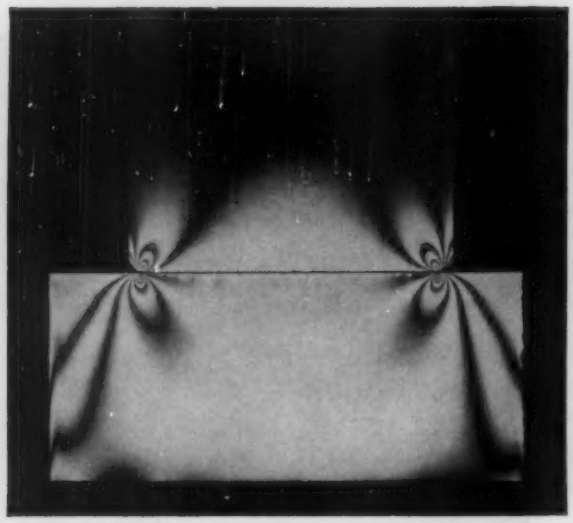
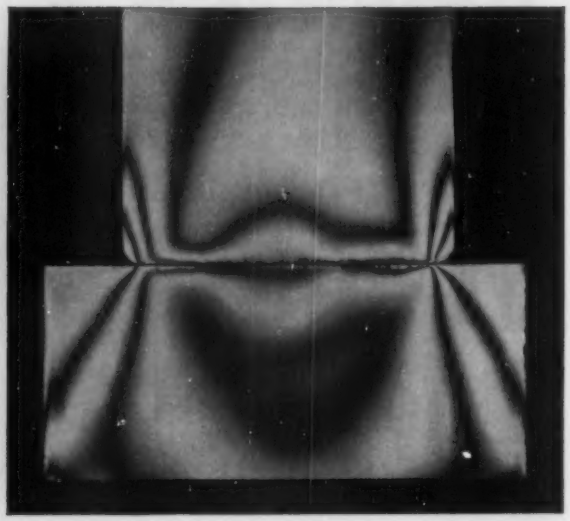
17

One in a series of technical reports by Bower

BEARING BRIEFINGS

ROLLER BEARING LIFE AND CAPACITY LINKED TO STRESS DISTRIBUTION





These reproductions of photoelastic studies contain important evidence for every engineer and designer concerned with the performance and selection of roller bearings. In these photographs, the alternate dark and light areas, called fringes, indicate not only the magnitude of stress but also the stress distribution. The photographs were taken by Bower Research Engineers during a study of stress distribution in roller bearings.

The subjects represent rollers and raceways of two roller bearings under identical loads. The illustration at the left shows a roller of conventional design. The illustration at the right shows a Bower "Profiled" roller. That is, the roller is precision ground with a large radius generated along the body of the roller—a predetermined and controlled distance from each end.

The conventional roller photo (left) clearly shows how, under load, stress concentration builds up in and near the roller ends. This is called edge-loading. Such areas of concentrated stress are the breeding grounds for metal fatigue and eventual bearing failure.

In the photo of the "Profiled" roller (right) stress lines can be seen uniformly distributed across the whole length of the roller and raceway. There are no points of excessive stress concentration, consequently no starting points for early fatigue. Such a "Profiled" roller exhibits a great advantage in improved load carrying capacity, a most important bearing requirement.

Under actual operating conditions, Bower "Profiled" roller bearings show a considerably longer life at higher speeds and under greater loads than conventional roller bearings.

Because of this, and of other Bower features to be discussed in later technical reports, we suggest that you consider the advantages of Bower bearings in satisfying your future bearing requirements.

★ ★ ★ ★

Bower engineers are always available, should you desire assistance or advice on bearing problems. Where product design calls for tapered roller bearings or journal roller assemblies, Bower makes these also in a full range of types and sizes.

BOWER ROLLER BEARINGS

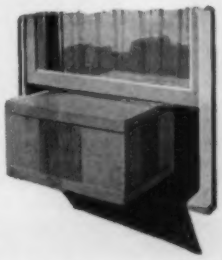
BOWER ROLLER BEARING DIVISION — FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

Better Products Through Better Methods and Steels

Above: unpainted air conditioner cabinet

How modern zinc-coated steel sheets keep air conditioners weatherproof—season after season after season.

When cold-rolled sheet steel formed the cabinets and special drawn base pans of air conditioners, they were primed and painted inside and out to protect them from constant exposure and functional moisture. Even so, corrosion often took hold around fastenings, louver edges and scratches.



Now that Weirkote continuous-process zinc-coated steel is used, the cabinet, louvers and chassis can be cut, bent and formed (even worked to the limits of the steel itself) without chipping or flaking the corrosion resistant zinc surface. When the outside paint finish is applied (primarily for decoration) the air conditioner has the double protection of a coating of paint and a coating of zinc assuring corrosion-free service for many years to come.

It's because of this weather-shedding surface, this superior formability that continuous-process zinc-coated steel is more and more the metal specified for air conditioning, heating and ventilating equipment.

A major supplier: Weirton Steel Company—producer of Weirkote continuous-process zinc-coated steel and many other steels that improve products, methods and profits throughout industry.

Galvanized Steel

Look for the STEELMARK on the products you buy; place it on the products you sell.

WEIRTON STEEL
Weirton, West Virginia

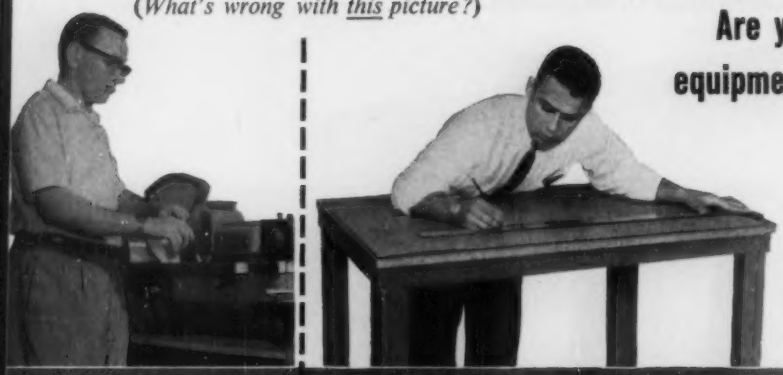
WEIRTON STEEL COMPANY

Weirton Steel is a division of **NATIONAL STEEL CORPORATION**

Weirkote will also be available in 1961 from National's Midwest Steel Division, Portage, Indiana

CIRCLE 49 ON READER SERVICE CARD

(*What's wrong with this picture?*)



Are your mailboys working with better equipment than your engineer-draftsmen?

Your mailroom equipment is expensive —but, because it does essential work, it pays off. However, you may be badly handicapping some of your most *skilled, professional talent*— your drafting men—if they're still working with antiquated, inadequate, uncomfortable equipment.

Your draftsmen, your productivity, deserve new Hamilton space-and-time-saving equipment— from Post

For its cost, Hamilton drafting equipment will produce more marked improvement in efficiencies than any other equipment expenditures in your plant.

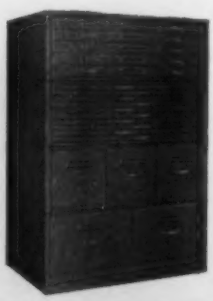
It steps up productivity—directly and unmistakably—because: (a) construction and design features insure greater accuracy, consistent performance; and (b) anatomy-conscious design greatly reduces fatigue, permits the exact work positions and heights best suited for individual jobs.

Hamilton equipment *continues* to deliver this superior ease and performance, because it is so carefully constructed, of such quality components, that it outlasts ordinary equipment by many years. It *stays* modern, because it totally conforms to individual needs.

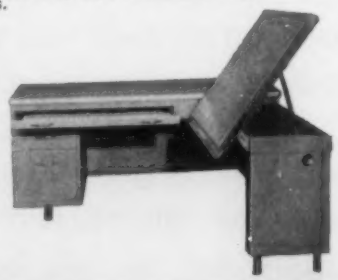
Shown here are three of the many products in the complete Hamilton line. Learn about the many other units Hamilton offers. Our expert planning personnel can be of considerable assistance, suggesting the arrangements best for you.

Hamilton De Luxe Auto-Shift Table
You'll get peak productivity and greater work quality from your board men when equipped with the new Auto-Shift. It is considerate of comfort, and delivers wide flexibility of adjustments.
Perfect, fully seasoned drawing surface; front-to-back filing in full-width drawers; stylized leveling legs . . . many more functional and styling features.

Hamilton Interlocking Plan Files
Provide greater protection, accessibility, and classification. Assembly shown includes (top to bottom) 5-drawer unit for semiactive material, 10-drawer section with tracing lifter that makes every sheet as accessible as a top sheet, and two vertical drawer units. Interlocking roll tracing unit also available. Interlocking caps and bases, with latter available for variety of stack heights. Rugged construction, smooth drawer action, trim beauty.



Hamilton L-Contour Table
While occupying very small space, this table provides man-sized, fully comfortable work area. Board fully adjustable from horizontal to vertical. Working surface exceptionally stable, perfectly balanced. Many other features—plus the quality of construction found only in Hamilton equipment.



For practical, down-to-earth help in solving your drafting room modernization problems, consult trained POST salesmen and dealer representatives for recommendations tailored to your needs. Or, write Frederick Post Company, 3650 North Avondale Avenue, Chicago 18, Illinois, for information on the complete line of POST drafting materials and engineering supplies.

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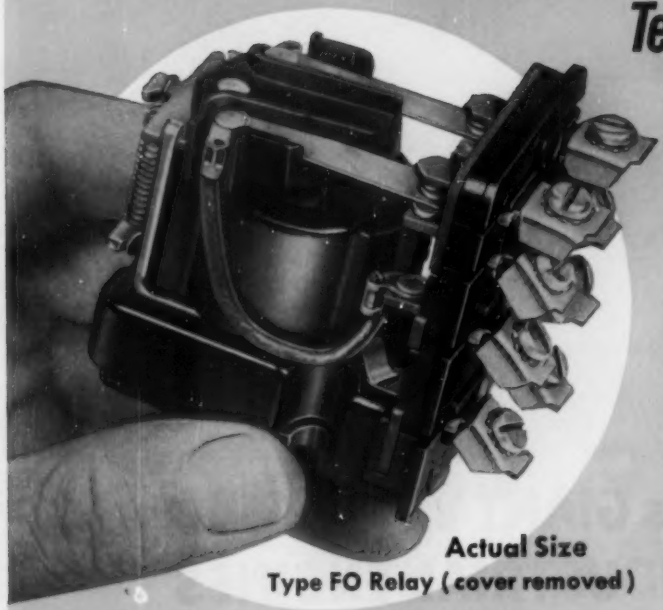
CIRCLE 50 ON READER SERVICE CARD

NEW from Square D...

A SMALLER 10 AMP RELAY— WITH INDUSTRIAL FEATURES!

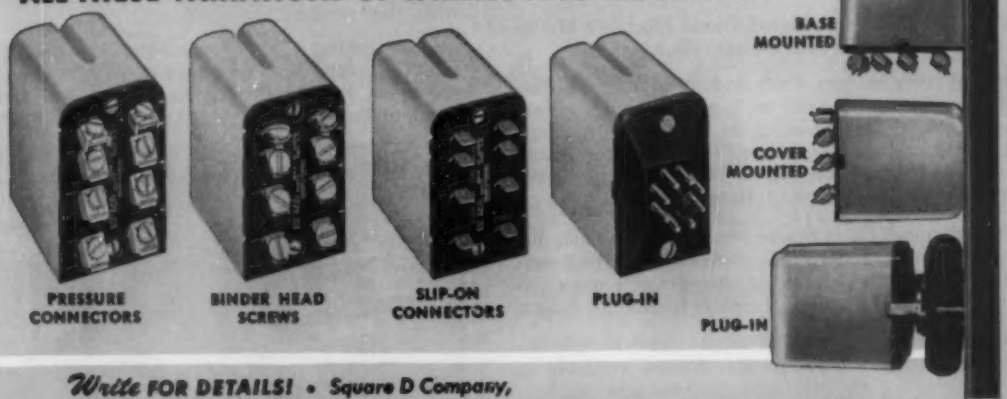


Actual Size
Type FO Relay (cover removed)

Terminal or Plug-In Wiring

- **RATINGS** easily handle solenoid loads. AC pilot duty rated 690 VA. Continuous rating 10 amperes, 125 volts AC for plug-in construction and 277 volts AC for terminal connection
- **Long Life** makes suitable for rugged machine tool applications
- **Molded coil** operates cooler and keeps out moisture for longer life
- **No solder joints** to break
- **Optional pilot light** indicates when relay is energized
- **Durable nylon dust cover** won't break, crack or support combustion

ALL THESE VARIATIONS OF WIRING AND MOUNTING

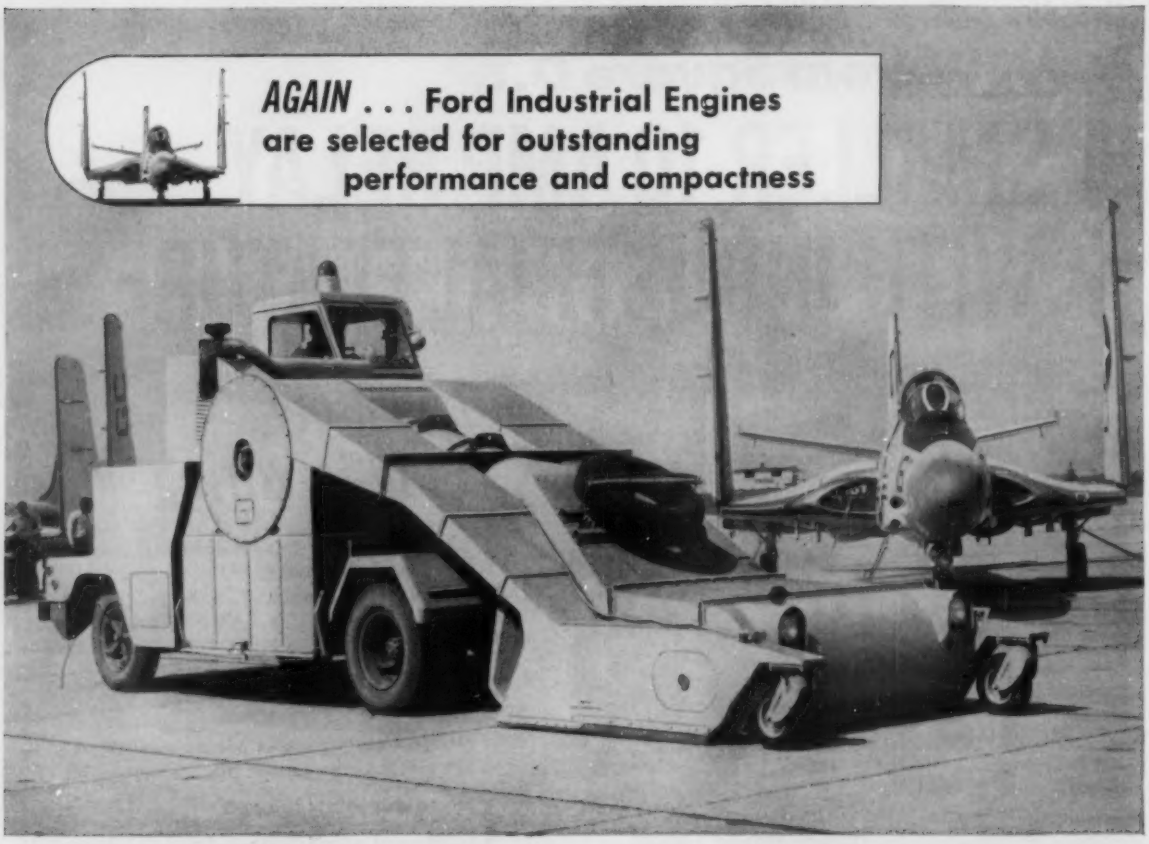


Write FOR DETAILS! • *Square D Company,*
Dept. SA, 4041 North Richards Street, Milwaukee 12, Wisconsin

SQUARE D COMPANY

wherever electricity is distributed and controlled

CIRCLE 51 ON READER SERVICE CARD 51



Leading OEM powers GIANT VACUUM CLEANER with FORD INDUSTRIAL ENGINES

PROBLEM: How to keep airports free of dirt and debris that cause tremendous damage when "sucked up" by powerful jet engines.

SOLUTION: Use Consolidated Diesel Electric's Model 2095 Vacuum Sweeper shown above!

Powered by two modern Ford Industrial Engines, the Consolidated Sweeper is designed to clean one million feet of runway per hour . . . picking up such debris as sand, gravel, wire, nuts and bolts. Just as Ford power contributes to the effectiveness of this unit, it can bring a new kind of efficiency to your equipment. Here's why:

Ford's full line of Short Stroke engines are compact, durable and economical to operate. Ford's space-saving construction and *high power-to-weight ratio* also give you a distinct manufacturing advantage: greater freedom of design.

Ford engines range from 134 to 534 cubic inches—including two highly efficient diesels. All are available as complete engine assemblies or power units. And, remember, because Ford engines can be serviced by any local Ford Dealer, your customers can get quick on-the-job service when they need it.

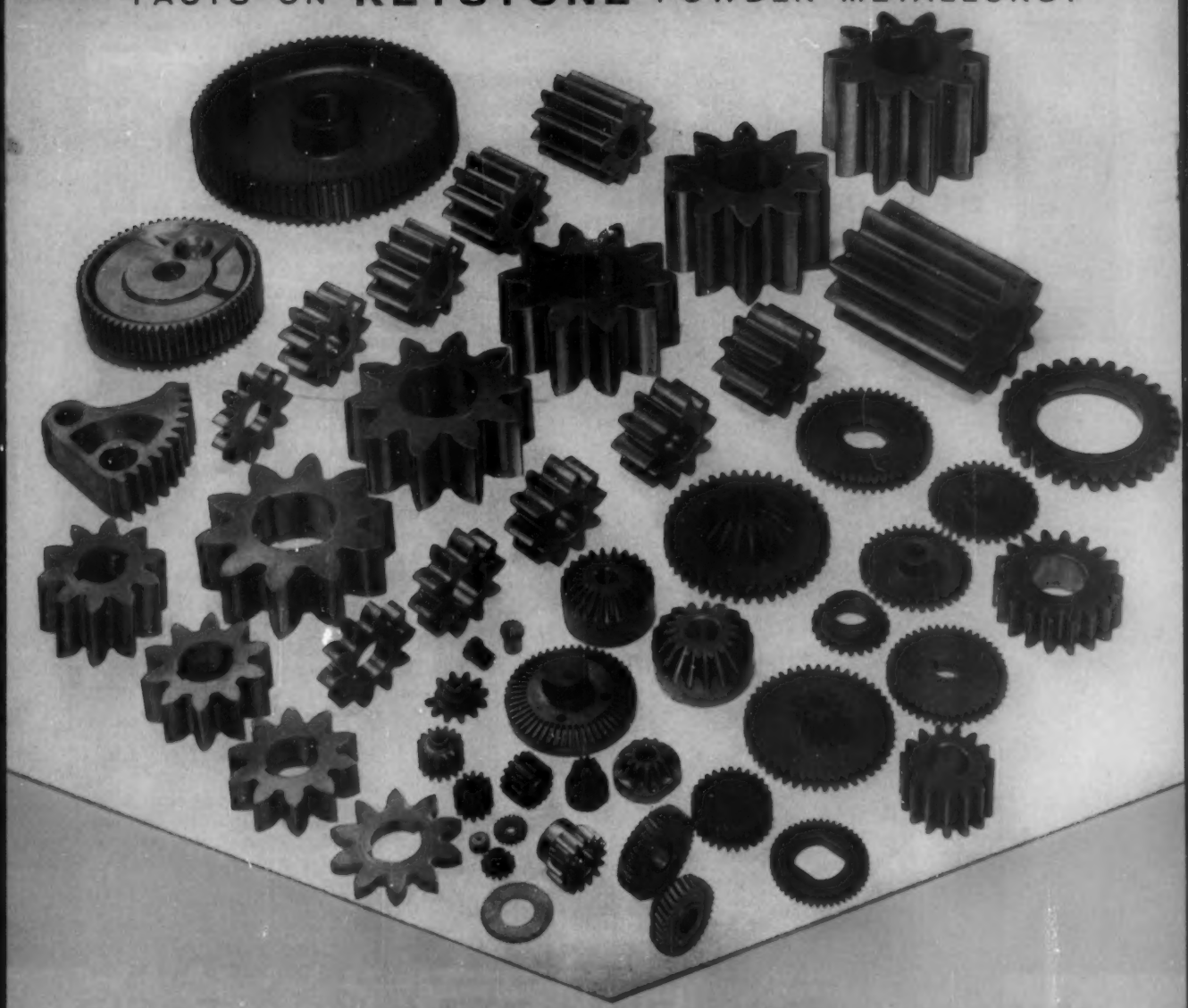
These are but a few of the important reasons why equipment designers, sales managers and top management are specifying Ford Industrial Engines. It will pay you to swing to Ford power if you haven't done so already.

FORD POWER IS RIGHT FOR YOUR EQUIPMENT, TOO!

INDUSTRIAL ENGINE DEPARTMENT, FORD DIVISION, FORD MOTOR CO., P.O. BOX 598, DEARBORN, MICH.

West of Rockies write to: → FORD INDUSTRIAL ENGINE DEPT., P.O. BOX 6787, LOS ANGELES 22, CALIF.
→ FORD INDUSTRIAL ENGINE DEPT., P.O. BOX 1666, RICHMOND, CALIF.

FACTS ON **KEYSTONE** POWDER METALLURGY



THE PLACE OF GEARS

IN KEYSTONE POWDER METALLURGY

A few years ago, the simplest gear shapes seemed remarkable in themselves as they came chuting from the powder metal presses. Those uncomplicated spur gears exemplified all the tenets of powder metallurgy—low cost, high volume parts that required no expensive machining, and delivered excellent service in the right applications.

But our progress has moved swiftly in sintered gears since those pioneer days. The development of better materials has opened up many new medium- and high-strength applications to powder metal service. Imaginative tool engineering and press design have made possible the widest range of gear types . . . clusters, bevels, pinions, sectors, helicals . . . saving progressively more money as designs become more complex.

Today, gear production at Keystone is major in importance. We can meet your requirements to the dot in type, material, quantity, delivery and performance. In brief, we're geared to serve. Call us!

Keystone CARBON COMPANY
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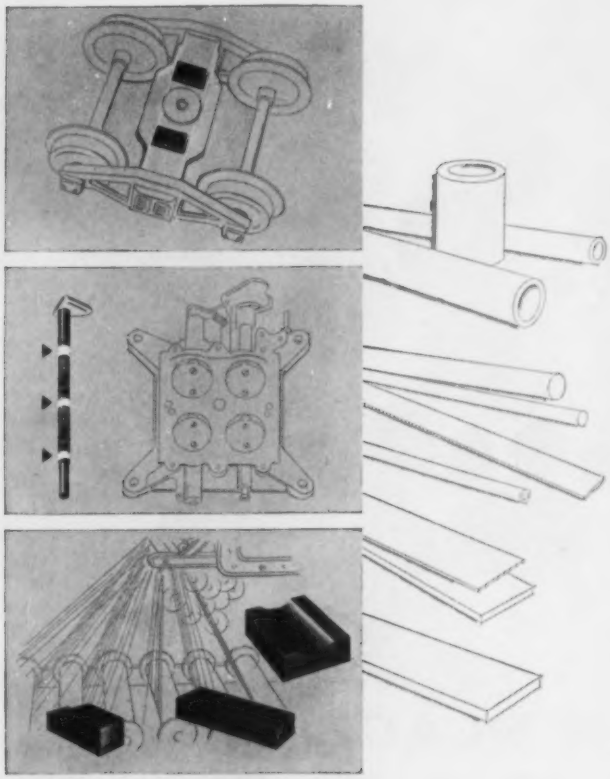
POWDERED METAL PARTS DIVISION

NEW TEFLON BEARINGS

for Non-lubricated Service



Railroad truck bearings (top), carburetor bearings (center), and saddle bearings for textile machinery (bottom)—fabricated from top-quality Teflon* stock by Garlock—offer performance unmatched by any other material.

Now—new bearings of Teflon eliminate lubrication . . . resist extreme temperatures and reactive chemicals . . . drastically reduce downtime.

No finer combination of properties. Bearings of Teflon offer a lower coefficient of friction than any other solid material; they have exceptional thermal stability and are suitable for continuous service to +500°F; they are completely resistant to nearly all chemicals and solvents; they are tough, abrasion-resistant, have no moisture absorption.

Applied where safety and reliability are essential. Teflon is used as journal and thrust bearings, and on other sliding surfaces where lubricated bearings are undesirable, or incapable of operation in extreme temperatures or corrosive conditions, or where there is a possibility of lubricant failure. Teflon bearings afford unexcelled performance where slip-stick motion must be minimized . . . on reciprocating and oscillating systems where the lowest possible static friction must be attained . . . where space and weight savings are essential.

Easily fabricated from high-quality Garlock stock shapes. Teflon bearings can be simply and economically made from standard Garlock tape, bar and rod stock available through local Garlock distributor outlets. Or, if you wish, Garlock will work to your exact specifications in furnishing bearings of all tolerances and size. Whatever the case, the key to best bearing performance is through the use of Teflon stock shapes by Garlock. With years of experience in research and processing of plastics, Garlock is able to recommend and furnish *exactly* what you need, when you need it, and at the lowest possible cost.

Find out more about Teflon bearings. Consult your local Garlock representative at the nearest of the 26 Garlock sales offices and warehouses throughout the U.S. and Canada.

Or, write for Plastics Catalog AD-177, Garlock Inc., Palmyra, New York.

GARLOCK

Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket Company

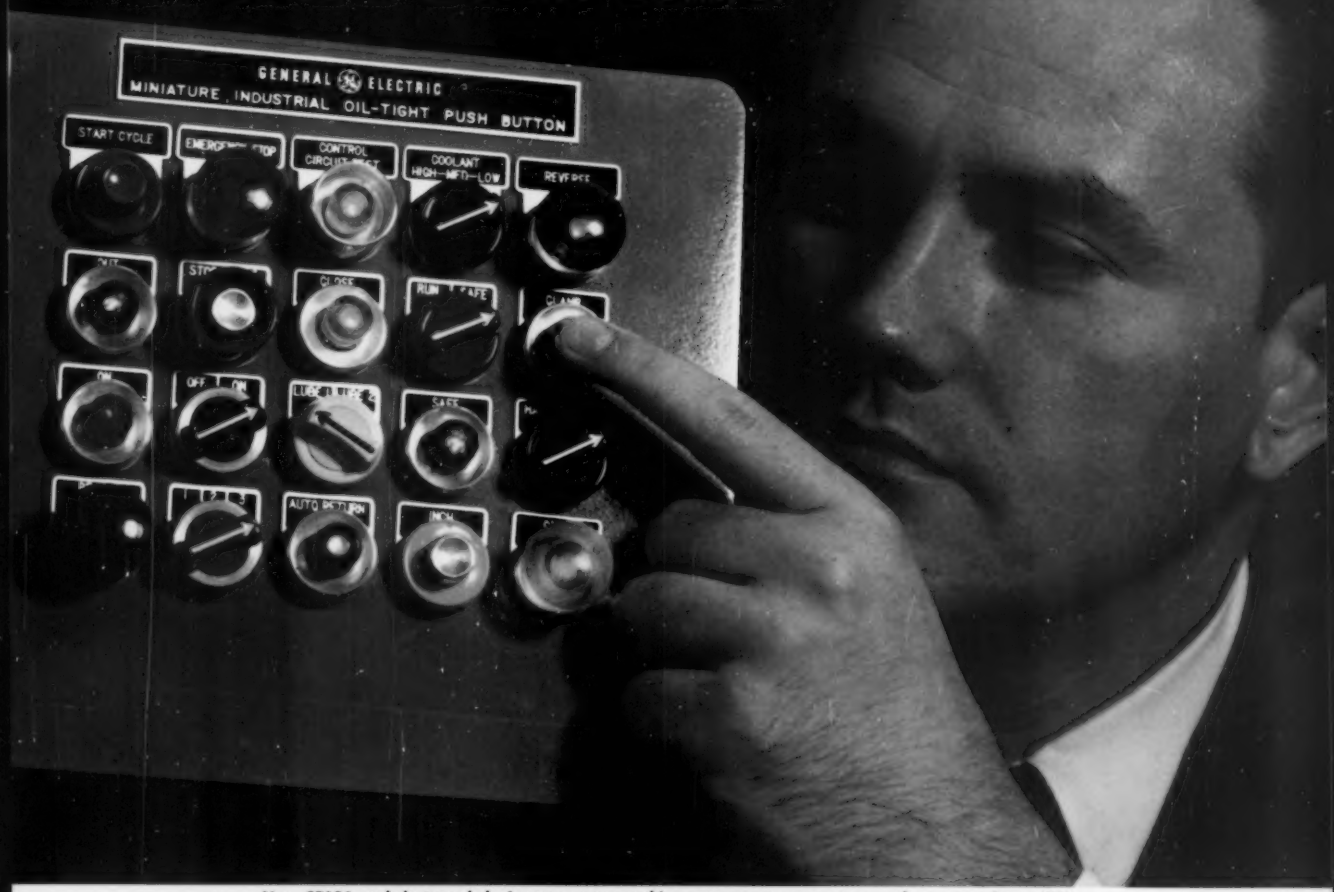
Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded & Extruded Rubber, Plastic Products

*DuPont Trademark

CIRCLE 55 ON READER SERVICE CARD→

New

Another Measurable Advantage from General Electric Control



New CR104 push buttons help improve your machine appearance, cut your panel space at least 40%.

FIRST COMPLETE LINE OF INDUSTRIAL MINIATURE OIL-TIGHT PUSH BUTTONS

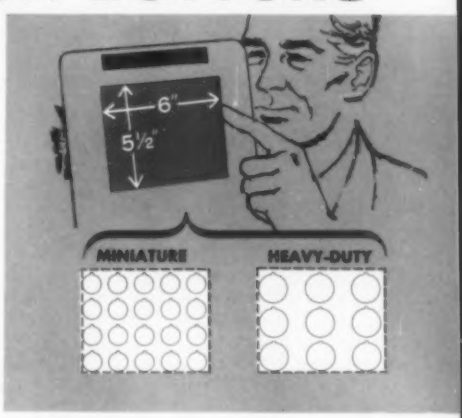
• Push buttons • Selector switches
• Illuminated push buttons • Indicating lights
• Push-to-test lights

Now you can design entire panels with miniature pushbutton units and cut your panel space requirements at least 40 per cent! General Electric announces the development and immediate availability of industry's first complete Industrial Miniature Oil-tight Pushbutton line.

This new CR104 line offers you the operating and functional units presently available in heavy-duty oil-tight forms —with an attractive appearance that enhances the design of your machines. A wide variety of operators is available, plus various modifications, special units, and nameplates to meet every operating requirement. Color coding is available in *both* operators and rings to provide you the flexibility of many different color combinations. Also, enclosures and pendent stations are available to accommodate from four to 42 units.

FOR MORE INFORMATION on this outstanding new development in control—and the "measurable advantages" it offers you—contact your nearby G-E Apparatus Sales Office, or write for Bulletin GEA-7127, General Electric Co., Schenectady 5, N. Y. 811-10

You get
MEASURABLE ADVANTAGES
WITH GENERAL ELECTRIC CONTROL



SAVE PANEL SPACE. Twenty new General Electric miniature units fit into the *exact* space required for nine heavy-duty oil-tight push buttons.

GENERAL ELECTRIC

RB&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By Fred E. Graves

Fastening of "blind hole" joints

Holes which don't go all the way through a solid member must be tapped, of course. In shallow, small holes, in non-critical fastening, and in soft materials thread cutting screws work well and save time.

But fastening large flanges, pressure plates, heads and the like to costly castings needs more precise production. These holes are ¼" diameter and larger, affect design strength.

THREAD EFFECTS

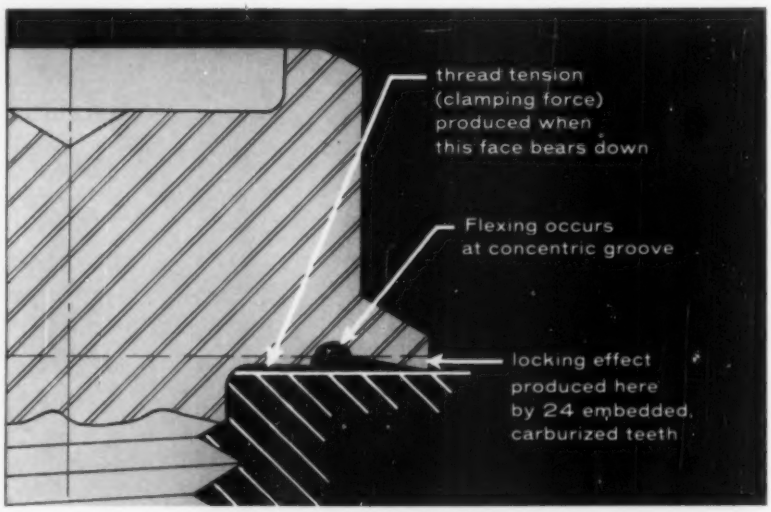
Such holes are coarse threaded. The coarse threads develop more thread strength than do fine threads, also take fewer turns in assembly. Studs go into the holes with an interference thread fit; hex screws with a simpler clearance fit.

Desirably, studs should all be driven to same depth and bottomed. Because of normal manufacturing differences, various mismatched high and low tolerances will cause studs to project unevenly. Assemblers often have to juggle. No such problem exists with hex screws. You just tighten to specified preload. And there's no double driving operation, as with stud plus nut.

STRENGTH OF BLIND JOINTS

Tapped holes behave like nuts. Their threads adjust elastically and plastically to distribute stress and develop high thread tension. Is this harmful in repeated disassemblies? Not at all. Hex screws have been installed 50 times in cast iron test blocks, then tightened to failure without damage to tapped holes.

Clamps like a hex screw Grips like an anchor


thread tension (clamping force) produced when this face bears down
Flexing occurs at concentric groove
locking effect produced here by 24 embedded, carburized teeth

Tensilock® screws offer you the ideal combination of high clamping force and high locking power.

While a standard high strength hex screw can be tightened to a higher thread tension, its off-torque is less than its on-torque.

ANCHORED IN PLACE

The *"Tensilock"* screw features ratchet action teeth formed at an angle which will cut driving effort to permit you to utilize more of the full strength of screw. At equal driving torque, it not only develops 90% of the strength of a high strength hex screw but also takes *25% more torque to loosen than to tighten.*

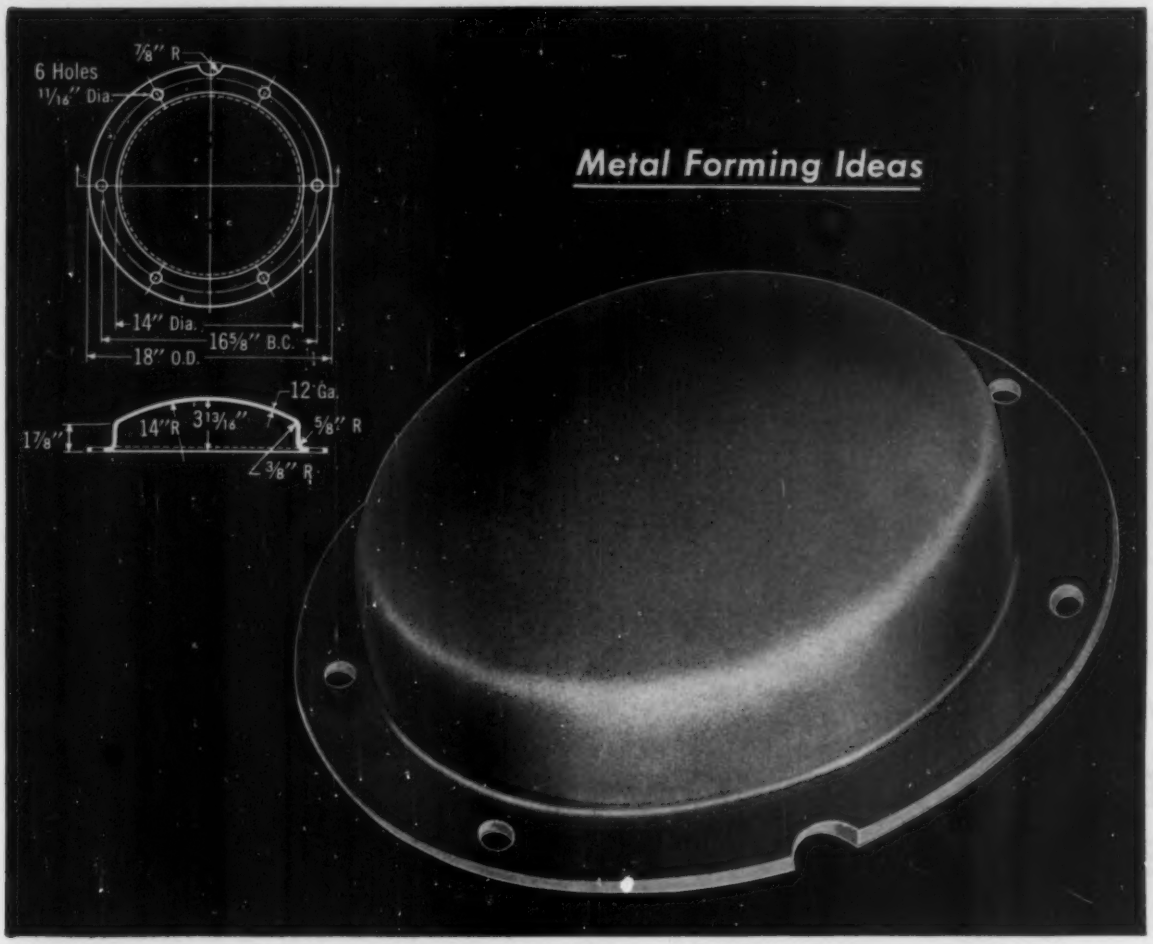
Because of the flange's concentric groove, it flexes, allows the screw to bear down solidly on its seat and develop a high level of thread tension. At the same time the teeth embed themselves, are aided in maintaining their grip by pressure of the spring-action flange.

MAKES GOOD FRICTION-TYPE JOINT

Clamping force from Tensilock fasteners is sufficient to prevent slippage of fastened members where holes are oversize or eccentric. Grip of the teeth keeps fasteners tight under conditions of vibration or cyclic temperature changes. RB&W *"Tensilock"* Nuts also available. Write for Bulletin TL-2. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

® Registered and Patented

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa., Pittsburgh; Detroit; Chicago; Dallas; San Francisco.



How to eliminate special tooling in the design of custom-formed parts

Custom stampings, formerly prohibitive cost-wise, can now be inexpensively formed through the use of existing dies from COMMERCIAL's "Die Bank" of almost 50,000 different forming die components.

A case in point: Wheel covers for American Coleman's aircraft towing tractor. They're important for the protection of the power transfer yokes in the tractor's four-wheel drive.

Stamping was first considered as the best method for forming them. The original low quantity involved and the amortization of $2,300 for special forming die costs, however, made the stamping unit costs impractical.

The covers were therefore first produced as machined, malleable iron castings at a cost of $8.49 per unit. A switch to hand spinning later reduced this cost to a still high $3.50 per cover.

American Coleman then discovered and investigated COMMERCIAL's "Die Bank". From 24 basic shapes ranging 4" to 72" in diameter and involving metal thickness from 20 gauge to ¾" —all available through the use of existing dies adapted to presses up to 2000 ton capacity—emerged an entirely practical and economical solution to the unit cost problem.

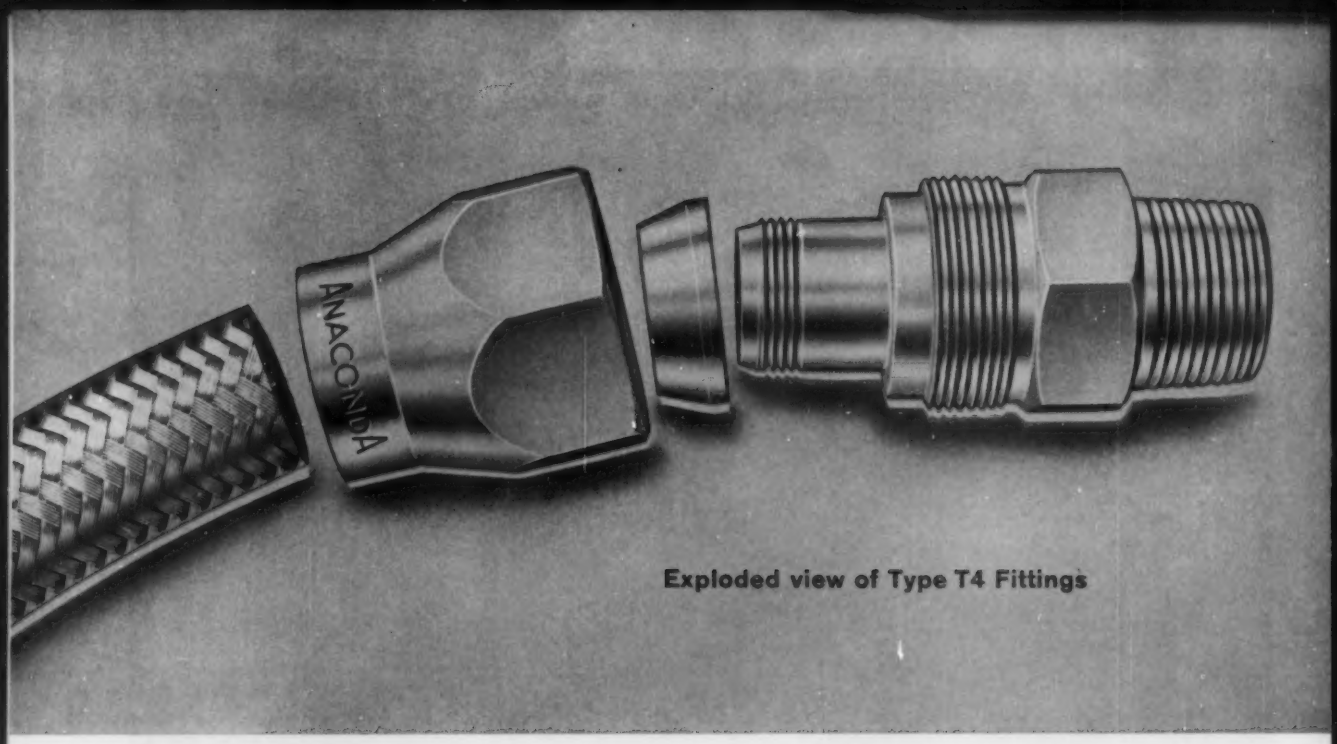
The design: A standard, dished, offset shape with vertical and horizontal flanges and dish radius equal to its dished diameter. The wheel cover of 12 gauge, stamped steel now provides complete protection, necessary yoke clearance and a pleasing appearance.

Best of all, by using an existing forming die from COMMERCIAL's "Die Bank", the actual tooling charge was only $80 for a simple modification of a single die component. And the unit cost was slashed to a practical $2.59.

The final result: A strong, lightweight wheel cover with a smooth surface for finishing which now completely and economically meets all requirements.

If your component requirement involves a custom-formed or unusual shape, and if the high cost of tooling prohibits its economical forming, the "Die Bank" service at COMMERCIAL may be just what you've been looking for. There's a quick way to find out. Just send along a blueprint, sketch or prototype of your part to Commercial Shearing & Stamping Company., Dept. **G-43,** Youngstown 1, Ohio.

COMMERCIAL
shearing & stamping



Exploded view of Type T4 Fittings

Tailor-made Assemblies—

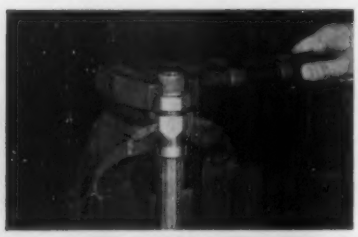
NEW ANACONDA TYPE T4 HOSE OF TEFLON* WITH REUSABLE FITTINGS

Now you can get stainless steel wire-braided hose assemblies of Teflon from your local Anaconda distributor. He can make them up to your exact needs in a matter of minutes, using simple hand tools. It's fast and easy.

Type T4 Hose takes the roughest service. The flexible core is tough virgin Teflon. It's reinforced with stainless steel wire braid for added strength. Reusable fittings for Anaconda Type T4 Hose are designed to withstand high working pressures and temperatures.

Where you can use Anaconda Type T4 Hose. Use it for general industrial uses to handle hydraulic and corrosive fluids, hot tar, steam, air, fuel, food, lubricants and gas—within a temperature range of −65° F through 450° F.

Anaconda Type T4 Hose is available in ⅛-inch through 1¼-inch actual inside diameters. Standard fittings for Type T4 Hose are available in cadmium-plated brass, N. P. T. males. To find out more about how this new assembly can help simplify your maintenance work, fill out the coupon and mail it today. 60126L



It's easy to attach, detach, and reuse Type T4 Fittings. All you need is a vise and a wrench.

*Dupont Trademark

ANACONDA®

METAL HOSE

CIRCLE 58 ON READER SERVICE CARD

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P. O. Box 791, Waterbury 20, Conn.

Please send me more details about New Anaconda Type T4 Hose and Type T4 Fittings.

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PRODUCT ENGINEERING HORIZONS

OCTOBER 17, 1960

SKIN DEEP

Comments of several readers* about our cover of July 25 point up a particular American foible that has given our sociologists and philosophers considerable cause for alarm. The cover in question showed nine men, engineers for Marchant, ranging from designers (four in shirtsleeves) through project engineers and specialists to vice-president–engineering (with coat and pocket handkerchief). The differences in dress were discriminatory, our critics said.

At the time I was somewhat amused. I suspected that special inducements had been necessary to get the whole crowd out of sport shirts for the photograph, and further that most of them consider a sport jacket and slacks about as formal as one can get in Southern California.

But further reflection on the subject suggests a more serious problem–the problem that we Americans are striving so hard to act, look and think alike. The herd instinct has become so strong that conformity is more important than contribution, sameness more vital than satisfaction.

Look around you. The undesirable is invariably the different–the non-TV home, until recently the non-finned automobile. And what is different is, by definition, a status symbol. Somewhere along the line we've developed a mass-production interpretation of democracy and made a caricature of the statement that "all men are created equal."

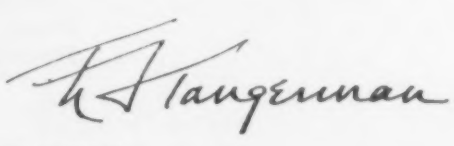
The sinister element is that our equality binge is only skin deep. We all fight to surpass–not keep up with–the Joneses. Of course the surpassing is always in degree, not in kind. Bigger fins, more TV sets, two cars in every garage. And we fight so hard we've lost any feeling of consideration or respect for our fellow man–the things he considers important or satisfying.

We had heard encouraging things about how several companies were starting to offer engineers parallel routes up the ladder. One way was the traditional one toward management, the second in a straight technical sense to some sort of senior-engineer position. We were all for it, feeling that many engineers will always make their best contribution to company and country if they stick with the path they started on, rather than to switch over to paperwork and human relations and business relations somewhere along the line.

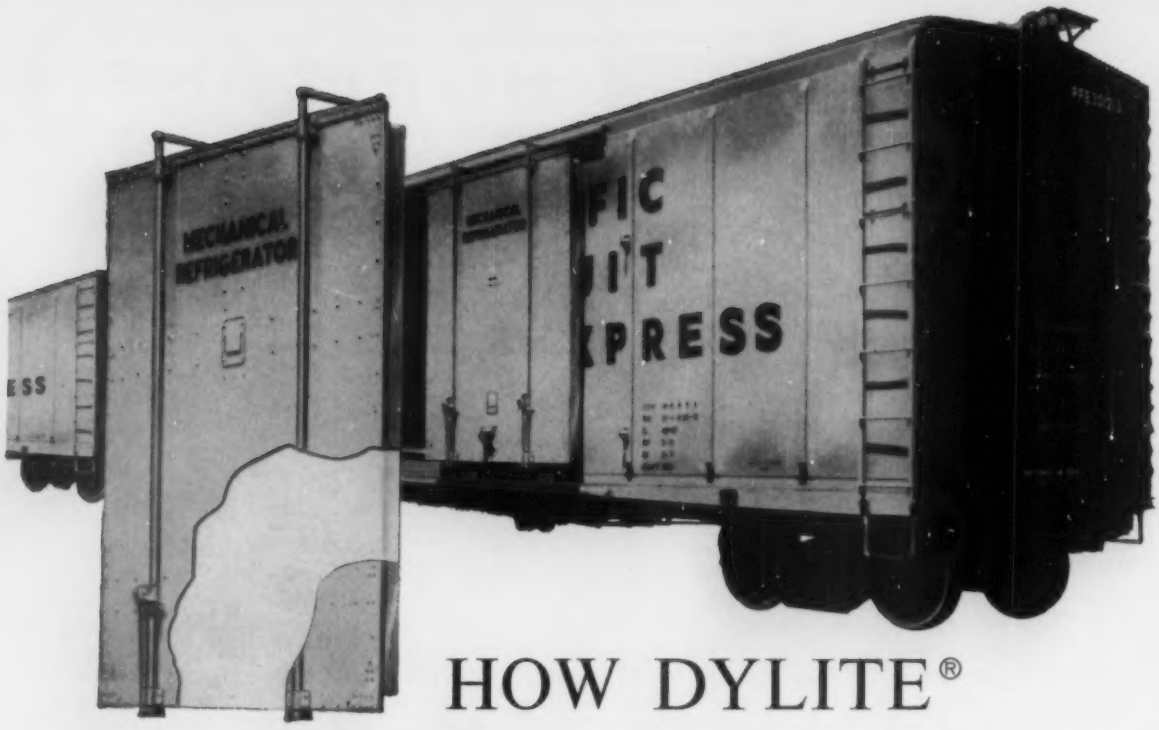
Well, the step to management means putting on a four-in-hand tie and a jacket, and accepting the strait jacket that being a figurehead and customer's man implies. It means you don't have time to get your hands dirty in a model shop. It means you don't have the stimulation of watching an idea born in your fertile imagination take form "in steel" under your hands.

This being the case, who has the more satisfying job–particularly for the type of mind that chooses engineering as a profession in the first place?

But apparently we're not concerned with job satisfaction or contribution anymore, only the appearances. We've been so sold on packaging that we're buying the shell instead of the egg, the can instead of the peaches, the box instead of the chocolates, and the haircut instead of the brains.



* A response to one of the letters, published Sept 19, appears on page 26



HOW DYLITE® GOT ITS FOOT IN A FREIGHT CAR DOOR!

This unique refrigerated freight car door is insulated with DYLITE expandable polystyrene. This lightweight foamed plastic forms a tight, moisture-proof, non-sagging insulation. DYLITE freight car doors improve insulation and weigh 400 to 500 pounds per car set less than conventionally-insulated doors. These doors are now being installed on 1,025 new refrigerated freight cars of the Pacific Fruit Express Company. The cars are temperature-controlled from –10°F to 70°F.

The door liner is molded of CYCOLAC* ABS plastic made by the Marbon Chemical Division of Borg-Warner Corporation. The idea to combine DYLITE with CYCOLAC came from Robert L. Landis, developer and manufacturer of the new door liners which are now manufactured by the Landis Industrial Company, Santa Clara, Calif.

DYLITE comes in the form of tiny crystal beads. When heated, these beads can expand up to 60 times their size and fuse; forming a light, smooth-skinned part at the desired density. DYLITE is a remarkable low temperature insulator having a K factor of 0.242 at 2 lbs./cu. ft. density and a 75°F mean temperature. It is low-cost, non-shrinking, and can be molded to almost any size or shape. In addition, DYLITE is strong, durable, moisture- and vapor-resistant.

For more information on the outstanding insulating qualities of DYLITE expandable polystyrene, write to Koppers Company, Inc., Plastics Division, Dept. PE10170, Pittsburgh 19, Pa.

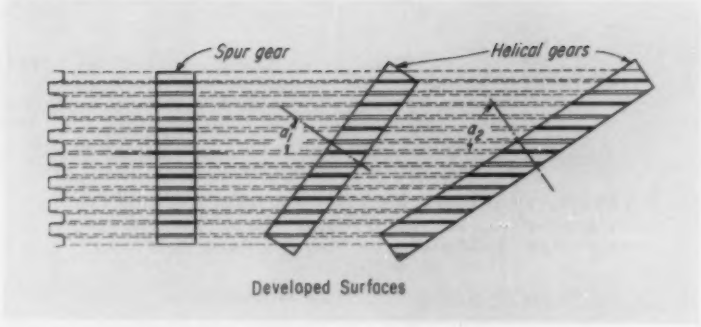
DYLENE® polystyrene, SUPER DYLAN® high density polyethylene, DYLAN® polyethylene, and EVENGLO® polystyrene are other fine plastics produced by Koppers Company, Inc.

**CYCOLAC is a registered trademark of Borg-Warner Corporation*

KOPPERS PLASTICS

PRODUCT ENGINEERING

WHEN HELICAL GEARS GET YOU OUT OF TIGHT SPOTS



BY VARYING HELIX ANGLE, spur gears can be replaced with helical gears to provide any number of workable pitch diameters, and add flexibility to design.

Their adaptability can overcome many difficulties in gear-train design that normally call for complicated, expensive measures.

SIGMUND RAPPAPORT, *kinematician,*
Ford Instrument Co, Div of Sperry Rand Corp
Adjunct professor, Polytechnic Institute of Brooklyn

Suppose that two shaft centers in a gear train are erroneously machined too far apart—or worst still, too close together. Or, suppose you wish to change the gear-speed ratio between two parallel shafts without changing the center distance. In each of the above problems, helical gears with the proper helix angle might do the trick.

There are even more design tricks possible: With nonparallel shafts, you can mesh gears of different size to operate at one-to-one ratio, or you can vary the relative sizes of the meshing gears to avoid, say, interference with another machine member.

And also, pairing helical with spur gears in an otherwise standard planetary system can boost the reduction ratio from, say 1:21 to 1:1600. I described this innovation in a previous article (*PE—June 22 '59, p 67*), but key points will be reviewed here.

Helix Angle Is the Key

The pitch diameter of a helical gear of a given pitch is not related in a simple linear proportion to the number of teeth—as is the case with spur gears—but is also dependent on the helix angle. In fact, for a given number of teeth and a given normal pitch, an infinite number of workable pitch diameters is possible. The smallest, based on a helix angle of zero, is identical with the pitch diameter of a spur gear of the same number of teeth and diametral pitch (see illustration above).

Although the tooth form and its proportions are based on the normal diametral pitch, the size of the helical gear—that is, its pitch diameter—is determined by the circular pitch, which changes with the helix angle.

Pitch dia D, of a spur gear is found from

$$D_s = n/P$$

where n is the number of teeth and P is the diametral pitch.

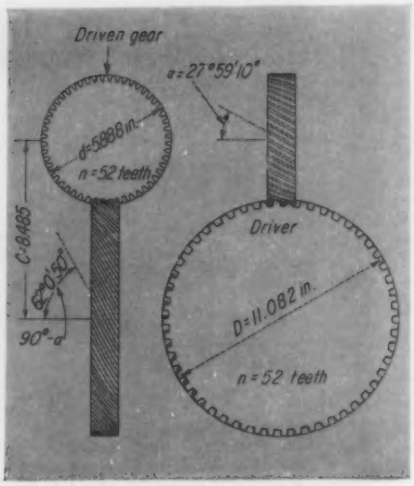
Pitch dia D of a helical gear is

$$D = \frac{n}{P \cos \alpha}$$

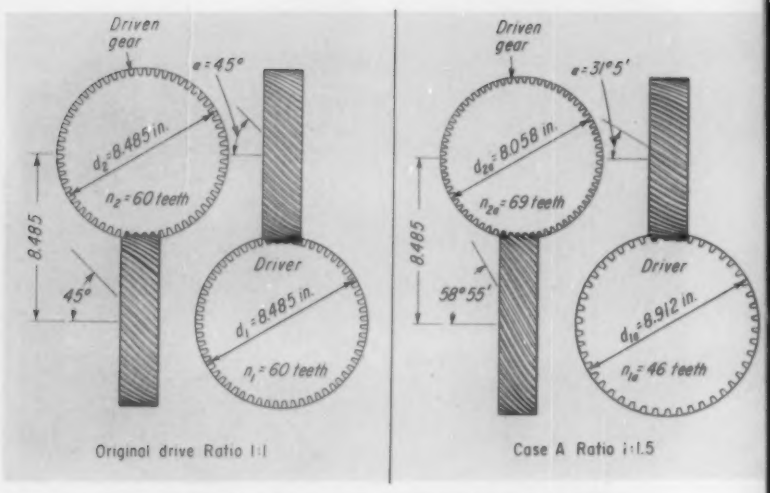
where α is the helix angle (angle between the tooth direction and gear axis).

As can be seen from this equation, the minimum D

REPRINTED—Circle P65, inside back cover



GEARS OF DIFFERENT PITCH diameters can give ratio of 1:1 by varying the helix angle.



VERSATILITY of helical gears makes it possible to keep the same gearbox while varying the input-to-output ratios to suit requirements. Modifications are shown in Cases A, B and C.

occurs at $\alpha = 0$, which is a spur gear. Center distance between a pair of helical gears is a variable; and from these equations it can be seen that it is never smaller than the center distance between a pair of spur gears of the same pitch and number of teeth.

Compensating for Center-distance Errors

If two shaft centers are erroneously machined too far apart, the error can be compensated for by replacing spur gears with helical gears. The required helix angle α is then found from

$$\cos \alpha = C/C_e$$

where C is the center distance which should have been applied and C_e is the one actually put in.

An incorrect center distance sometimes can be compensated for when it is smaller than the theoretical one. Suppose two parallel shafts are to be connected by a pair of gears having 60 and 90 teeth, respectively, and a diametral pitch of 24. The pitch diameters of the gears are $60/24 = 2.5$ in., and $90/24 = 3.75$ in. Correct center distance is $\frac{1}{2}(2.5 + 3.75) = 3.125$ in. However, this distance is erroneously machined to 3.012 in. Spur gears can't be used because the next smaller spur gear pair of same ratio will have 56 and 84 teeth, respectively, with a required center distance of 2.917 in. But helical gears, with 56 and 84 teeth can operate at 3.012 in., providing that their helix angle equals:

$$\cos \alpha = 2.917/3.012$$
$$\alpha = 14° 25'$$

One of the pair of helical gears will be left-handed, the other right-handed. This will create a thrust that must be absorbed by the bearings.

How to Change Gear Ratios

Here's how helical gears permit you to change the gear ratio between two parallel shafts—yet still keep the center distance unchanged. This problem sometimes occurs when a machine is being redesigned for a change in the size of the product.

Assume that the two shafts are connected by a pair of spur gears with diametral pitch of 12 and with 30 and 75 teeth respectively. The correct center distance for the shafts is 4.375 in.

It is now desired to change the ratio from 1:2.5 to 1:3.25. This necessitates a change in number of teeth. Dividing $(30 + 75)$ by $(1 + 3.25)$, gives $105/4.25 = 24.705$. Therefore, the pinion is selected to have 24 teeth. Number of teeth for the gear is $(24)(3.25) = 78$.

But spur gears of 24 and 78 teeth call for a center distance of 4.250 in. This problem is solved by employing a helical gear set with 24 and 78 teeth, and with a helix angle equal to:

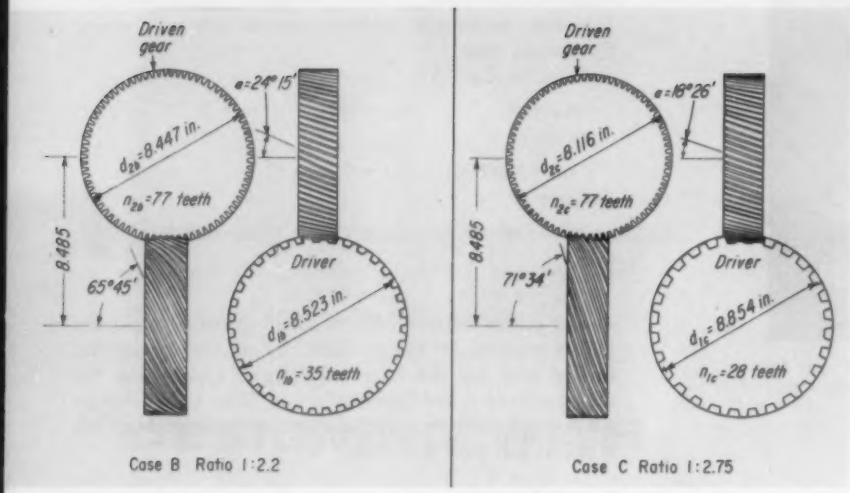
$$\cos \alpha = 4.250/4.375$$
$$\alpha = 13° 44'$$

With Nonparallel Shafts

The versatile helical gear can also solve design problems when crossing shafts are involved. Consider the case where a gear train in an automatic machine contains two shafts crossed at 90°, connected in a 1:1 ratio by a pair of identical helical gears (45° helix angle). The gears have a diametral pitch of 10, and 60 teeth each. (Pitch dia = 8.485 in.).

At first, the drive had merely an oil pan; later, it was decided to enclose the drive totally in a cast iron housing, but there was too little clearance between the upper (driven) gear and the frame to accommodate the housing.

Thus, the following problem arises: Maintain the center distance, the normal diametral pitch and the ratio, but reduce the pitch diameter of the driven gear from 8.485 in. to about, but not more than 6 in. and increase the pitch diameter of the driver accordingly. The following relations hold (see illustrations above):



$$d = \frac{n}{P \cos \alpha} \tag{1}$$

$$D = \frac{n}{P \sin \alpha} \tag{2}$$

$$C = \frac{d + D}{2} \tag{3}$$

where d = pitch dia of driven (upper) gear ≈ 6 in.
P = diametral pitch = 10
C = center distance = 8.485 in.
n = number of teeth
α = helix angle of driven gear
$(90 - \alpha)$ = helix angle of driver

Combining these three equations:

$$C = \frac{n}{2P}\left[\frac{(\sin \alpha + \cos \alpha)}{\sin \alpha \cos \alpha}\right] \tag{4}$$

Substituting the value for n in Eq (1) into Eq (4) gives a solution for α:

$$\text{cotan } \alpha = \frac{2C}{d} - 1 \tag{5}$$

Using this value in Eq (1) seldom yields an integral value for n. But, because d was not rigidly established (it was only postulated that d be not larger than 6 inches) it is sufficient to take the nearest whole number of n. Here $n = 52$.

Eq (4) can be rearranged to give:

$$\frac{2CP}{n} = \frac{\sin \alpha + \cos \alpha}{\sin \alpha \cos \alpha}$$

which can be easily solved for α by squaring both sides and making use of the identity $2 \sin \alpha \cos \alpha = \sin 2\alpha$. Thus

$$\frac{C^2P^2}{n^2} = \frac{1 + \sin 2\alpha}{\sin^2 2\alpha}$$

from which is found

$$\sin 2\alpha = \frac{n^2}{2C^2P^2} - \sqrt{\left(\frac{n^2}{2C^2P^2}\right)^2 + \frac{n^2}{C^2P^2}}$$

In this equation substituting values for n, C and P, gives: $\alpha = 27°59'10''$ from which we obtain

$$D = 11.082$$
$$d = 5.888$$

which yields the same center distance (8.485) as in the original pair.

Thus, a seeming paradox has been achieved of having two meshing gears of greatly differing size operating at a ratio of 1:1. This solution presents an additional bonus: axial thrust is reduced because the helix angle of the driven gear is less than 45°.

This solution would not have been possible if it were required to make the driver smaller and the driven gear larger, because beyond a certain point the helix angle exceeds the friction angle and the drive locks up.

Changing the Gear Ratio

This method can also be applied to use a given gearbox to accommodate a different gear ratio, while keeping the center distance constant. Here is an example:

Suppose you have a gearbox, built to accommodate two cross-shafts whose input-to-output ratio, R, is 1:1; and you want to use the same gearbox to produce the ratios listed below:

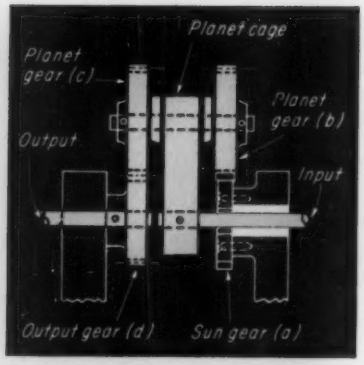
Case A — R_A = 1:1.5
Case B — R_B = 1:2.2
Case C — R_B = 1:2.75

Assume the original shafts have identical 60-tooth helical gears, with helix angle of 45°, diametral pitch $P = 10$ and pitch diameter of 8.485 in.

Find, for each of the three cases, the helix angle, α; the number of teeth in the driver, n_1; the number of teeth in the driven gear, n_2; the pitch diameter of the driver, d_1; and the pitch diameter of the driven gear, d_2.

These conditions should be met: center distance must remain 8.485 in., and gears should remain approximately the same size.

continued, next page



HELICAL GEARS in place of spur for one of the two sets boosts reduction ratio from 1:21 to 1:1600.

Since d_1 should be approximately equal to d_2 for each case, we find, with the use of Eq (1) and (2):

$$\frac{n_2}{P \cos \alpha} \approx \frac{n_1}{P \sin \alpha}$$

from which

$$R = \frac{n_1}{n_2} \approx \tan \alpha$$

This gives the following helix angles:

$\alpha_A = 33° 41'$ $\alpha_B = 24° 27'$ $\alpha_C = 19° 59'$

Next step is to determine n_1 and n_2 for Cases A, B and C.

Assume that $n_1 + n_2$ remains the same as in the original drive (120). Find whole-number values that will produce the desired ratio.

In Cases A and C the answers are:

Case *A*: $n_{1A} = 48$, $n_{2A} = 72$ Case *C*: $n_{1C} = 32$, $n_{2C} = 88$

But in Case B, there are no two whole numbers whose ratio is 1:2.2 and whose sum is 120. Since the ratio cannot be changed, the only alternative is to find integral solutions with a different total number of teeth:

$$n_{1B} = 35, \qquad n_{2B} = 77$$

But these data for numbers of teeth and corresponding helix angles would result in gear pairs with meshing gears of the same size:

$$d_{1A} = d_{2A} = 8.653 \text{ in.}$$
$$d_{1B} = d_{2B} = 8.458 \text{ in.}$$
$$d_{1C} = d_{2C} = 8.944 \text{ in.}$$

And if these gears were used with these diameters, the center distances for Cases A and C would be too large, and for Case B, too small.

This center distance for Case B can be enlarged to the required 8.485 in. by suitably modifying the helix angle, which is done most quickly by trial and error. Thus α_B is changed from 24°27′ to 24°15′, resulting in the pitch diameters

$$d_1 = 8.523 \text{ in.}$$
$$d_2 = 8.447 \text{ in.}$$

Half their sum yields the correct center distance of 8.485 in.

However, in Cases A and C, juggling of the helix angle cannot solve the problem because no solution can be found which simultaneously satisfies all requirements. Therefore, the sum of the teeth must be reduced, keeping the desired ratio.

Thus, for Case A:

$n_{1A} = 46$, $n_{1A} = 69$, $\alpha_A = 31° 5'$

resulting in

$d_{1A} = 8.912$ in., $d_{2A} = 8.058$ in.

For case C:

$n_{1C} = 28$, $n_{2C} = 77$, $\alpha_C = 18° 26'$

with

$d_{1C} = 8.854$ in., $d_{2C} = 8.116$ in.

The center distance of both these drives equals 8.485 in., as required by the problem. In all these cases the driving gear has the large helix angle, approaching the appearance of a multiple-start worm. This is not strange when one recalls that a single-start worm is nothing but a helical gear with one tooth.

Spur-helical Planetary

For the planetary system shown on this page the speed-reduction ratio is

$$R = 1 - \frac{ac}{bd}$$

where a, b, c and d are number of teeth or pitch dia of the respective gears. Here's where substituting a pair of helical gears for one of the spur-gear sets results in an extremely high ratio. For example, if $a = 39$, $b = 40$, $c = 41$, $d = 40$, the ratio becomes:

$$R = 1 - \frac{(39)(41)}{(40)(40)} = \frac{1}{1600}$$

To do this the helical pair (gears a and b) must have a helix angle equal to

$$\cos \alpha = \frac{a + b}{c + d} \qquad \alpha = 12° 45'$$

Limitation of an all-spur gear train is that the center distance between a and b must equal that between c and d. Hence for a similar train of $a = 40$, $b = 41$, $c = 40$, $d = 41$, the all-spur will produce a ratio of only

$$R = 1 - \frac{(40)(40)}{(41)(41)} = \frac{8}{1681} \approx \frac{1}{21}$$

Although a 1:1600 reduction is possible with a planetary system, the gain in torque is limited to about 40:1. This limitation also holds true for an all-spur planetary.

For REPRINT of above article, just check P65 on one of the Reader Service cards found in this issue.

EDITOR'S NOTE: For additional information on gear trains in recent articles see:

How to Predict Efficiency of Gear Trains, Aug 4 '58, p 44—New formulas and test data show how to compute power loss due to sliding action of involute gear teeth.

Epicyclic Gear Systems, June 13 '60—Gives equations for calculating volume, power capacity, speed ratios and stresses for spur or helical gear trains.

Epicyclic Gear-train Calculations, Apr '57, p 186—Shows step-by-step calculation of forces and speeds, by reducing the train to its component parts and analyzing the center member.

Stress Cycles in Planetary Gears, Jan '57, p 219—Tabulates formulas for number of stress cycles a gear tooth receives during its life.

Outstanding as a heat conductor—insulates against electricity. Here's a comparison with rival ceramics, and guides to . . .

DESIGNING WITH SINTERED BERYLLIA

ADOLF J STROTT, *plant manager*
National Beryllia Corp

Though it's an electrical insulator, the thermal conductivity of sintered beryllium oxide matches that of aluminum metal. That, in brief, is what this ceramic offers along with its high-temperature structural properties.

This abnormality (thermal and electrical conductivity usually go hand in hand) makes beryllia ceramic particularly useful for structural components that must isolate electrical parts, yet conduct their heat away. Although weaker than the pure-alumina ceramics now serving in these applications, it has better thermal shock resistance and a higher service-temperature range—up to 4000 F. But, like other ceramics, it has low tensile properties and definite tolerance limitations when used as fired.

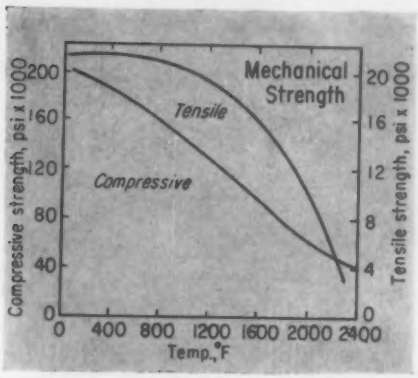
Main advantage offered by the new ceramic is its high thermal conductivity. This gives a composed part of sintered BeO its superior resistance to thermal shock and keeps its sintered properties uniform throughout the structure. The heat conductivity is outstanding—highest of the pure oxide ceramics, over 7 times that of alumina, and surpassing that of some common metals. Also, its high specific heat, 0.24 cal/gm, is more than twice that of alumina.

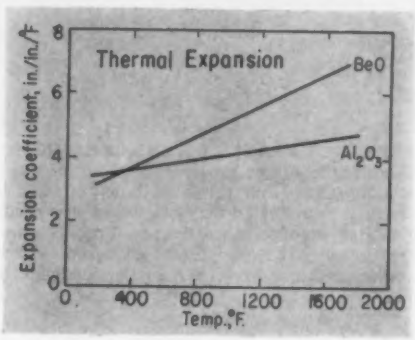
PROPERTIES OF THE CERAMIC

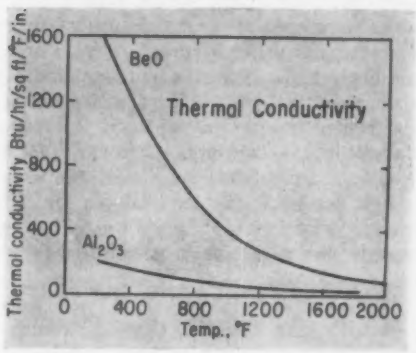
Physical and mechanical properties of dense BeO ceramic are given in the charts at right for room and elevated temperature. Table I, next page, compares sintered oxide with other high-purity, high-density oxide ceramics.

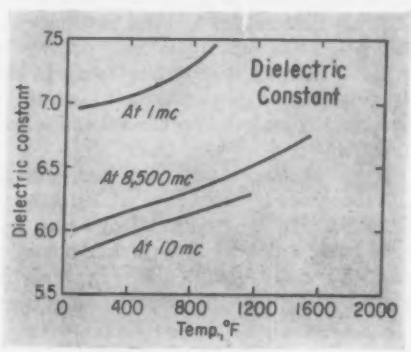
As-sintered strength of BeO goes down when density is less than 100%, but unless premium costs of maximum density and its other disadvantages can be justified, density should not be specified. Normal density that can be

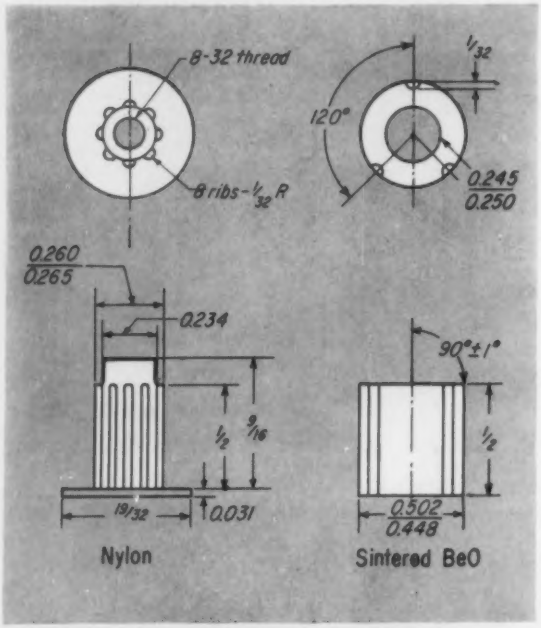
HOW BEO PROPERTIES CHANGE WITH TEMPERATURE











SIMPLIFIED SHAPE LOWERS CERAMIC COST. Original design for insulator prescribed nylon, included such details as flange, ribs and threaded hole—difficult to form in a ceramic. In redesign for BeO, flange was eliminated, insert in center hole replaced tapped thread, grooves replaced ribs. Final part is twice cost of nylon original but better cooling prolongs life of attached semiconductor component.

Table I—Properties of 5 High-purity, High-density Oxides

	BeO	Al_2O_3	ZrO_2	MgO	ThO_2
Melting Point, °F	4650	3700	4830	5070	5970
Max Temperature (in oxidizing atmosphere), °F	4350	3540	4530	4350	4890
Hardness, Moh Scale	9	9	6.5	6	6
Density, gm/cc	3.0	3.97	6.1	3.6	9.7
Thermal Conductivity, btu/sq ft/hr/°F/in.					
at 212 F	1525	209	14	250	73
at 1110 F	325	64	14	84	293
at 1830 F	142	43	17	49	20
Thermal Shock Resistance	Excellent	Good	Fair	Fair	Poor
Compressive Strength, psi					
at 68 F	200,000	427,000	300,000	.....	214,000
at 590 F	110,000	185,000	.....	.....	71,000
at 2200 F	50,000	71,000	114,000	.....	28,500
Electrical Resistivity, ohm-cm					
at 212 F	$8x10^{13}$	$1x10^{15}$	$1x10^{8}$	.....	.....
at 2200 F	$3x10^{12}$	$2x10^{6}$	.....	$8x10^{11}$	$2x10^{4}$

expected in slip-cast parts is a minimum of 90%; in extruded parts—95%; and in cold pressed parts—97%. Density is influenced by size and shape. In general, small compact parts made by these processes will have higher densities. Hot-pressing or sintering under pressure will produce densities over 99% regardless of size of part, but this tactic has two disadvantages: It limits service temperature in oxidizing atmosphere to 3000 F because of carbon contamination from molds; and it is expensive.

High density is not required for gas tightness but is required in nuclear applications where the maximum number of Be atoms must be crowded into a given space.

FABRICATING THE PART

As with most ceramics, shrinkage during firing makes close tolerances difficult to hold. Shrinkage for sintered BeO is high—between 15 to 30%—and varies from batch to batch. Because this material is toxic while in powder form, production lots so far have been limited to 30-lb batches—a quantity that can be safely handled. Shrinkage is determined for each batch and the unfired part (greenware) is made to dimensions which compensate for shrinkage.

As-fired tolerances vary with the process chosen to form the unfired part. Slip-cast parts have the widest tolerances, 5%. Tolerances of 2½% can be held in extruded parts and 1 to 1½% in cold-pressed parts. Hot-pressed parts are almost always ground to dimension, because carbon from the graphite molds contaminate the surface.

Machining is costly because this oxide must be ground with diamond abrasives. Although fine tolerances can be had, material-removal rates are slow. If firing cannot meet the required tolerances, grinding should be limited to one or two flat surfaces that can be surface-ground—the method that costs least. Next cheapest is centerless grinding; ID grinding is the most expensive.

Largest size that can be cast is 4 in. dia, with a height of 8 to 10 in. Maximum size of extruded section is 1 in. dia (with or without holes) and length is limited by furnace size (now about 24 in.). Parts up to 5 in. dia can be pressed but here the height should not exceed the diameter.

Thin parts can be ground from thicker stock. Flat pieces as thin as 0.015 in. can be readily made, and thinner pieces—to 0.005 in.—are possible if part is less than 1 in. in dimension. Minimum wall in 1-in. tubing is about 0.040 in.

THERMAL STRESSES

Designing ceramic parts to carry compressive loads is only part of the problem. Many ceramics fail because thermal stresses, which build up from heating and cooling, cause cracking. A helpful comparison when selecting materials for resistance to thermal stresses in steady-state conditions is the quantity $E\alpha/K$, where E is the elastic modulus, α is the expansion coefficient, and K is the thermal conductivity. A material with a high value for this parameter will be more susceptible to thermal-stress buildup than a material with a low value.

Table II—Thermal-stress Susceptibility of BeO Ceramic

	Elastic Modulus, (E) psi × 10^6	Expansion Coefficient, (α) in./in./°F × 10^6	Conductivity, (K) btu/hr/sq ft/°F/in.	Thermal-shock Parameter $E\alpha/K$
		Compared with Metals at 1000 F		
Nickel	28	8.3	420	0.55
Titanium	12	5.4	96	0.67
BeO	48	5.0	348	0.69
AISI 1020	24	8.2	250	0.79
AISI 410	25	7.7	205	0.94
AISI 347	23	9.6	150	1.47
		Compared with Oxide Ceramics and Carbides at 1800 F		
SiC (nitride-bonded)	9.5	2.5	109	0.22
BeO	37	6.7	102	2.4
MgO	30	7.5	49	4.6
TiC (cobalt-bonded)	60	5.0	58	5.2
Al_2O_3	51	4.9	44	5.7

The quantity is most useful for comparing similar materials—that is, metals with metals, and ceramics with ceramics. Other properties must be considered when a ceramic is compared with a metal, as shown at top of Table 2. Although beryllium oxide has a thermal-shock parameter smaller than those of stainless and other steels, it is more prone to cracking because it also has lower strength and ductility.

In general, ceramics should have more uniform shape than metals because their poor ductility does not redistribute the stresses. Although BeO can be quenched into water from red heat, this low susceptibility to thermal stress can be lost through a poorly designed shape that contains notches or other stress concentrators. At 1800 F, silicon carbide has lower thermal stress susceptibility but is a poor electrical insulator.

DESIGNING WITH BeO

The change-over to sintered beryllia usually involves parts that have previously been made from two types of materials: from another ceramic or from a plastic.

Switching to BeO from a well-designed ceramic insulator made of alumina is relatively simple. Walls should be heavier to compensate for lower strength (tensile, compressive and mechanical impact strength in BeO are lower than for high-purity, high-density alumina). Corrosion rates from mineral acids are higher but need only be considered if the part is to be used for chemical ware. Cost for the BeO will be about 7 times that of Al_2O_3 for a small quantity but in quantity production can be expected to be no more than two to three times as costly.

Going over to BeO from a plastic is more complex. Most plastics can be pressure-injected into complex molds and assume the close tolerances built into the die. Ceramic powders on the other hand do not flow in the cavity and their variable shrinkage makes complex close-tolerance dies impractical. Small detail and undercuts molded into plastics must be ground into ceramic parts. Holes pressed or extruded in the unfired part usually cannot be held closer than ±5% in roundness or center-to-center distance. Although drilling gives better tolerances, it is expensive, and generally should be avoided. Tapping or threading is even more costly.

Producing an equivalent molded-plastic shape in BeO is not economically practical. This type of direct transposition can lead to costs going up forty times or more. But if the parts are simplified to meet good ceramic practices requiring no more than as-fired tolerances, the cost jump can be as low as two to three times that of the original plastic part. A typical redesign—nylon to BeO—is illustrated at top left on the facing page.

FASTENING THE PARTS

When BeO is used primarily for its heat conductivity, heat transfer across a joint is the first consideration in fastening parts. Large flat surfaces held in contact by springs or clamps give best heat transfer. These areas should be surface-ground to eliminate slight waviness found in as-fired parts.

If two surfaces must provide a vacuum or pressure seal, the ceramic can be metallized, and then the two surfaces brazed together. Here, unlike metal-to-metal joints, heat transfer becomes less because the brazing adds two interfaces—ceramic-to-metal and metal-to-ceramic—through which the heat must pass.

Where temperatures permit, structural adhesives, either organic or ceramic, are a good fastening technique because they distribute loads evenly through the joints. Most adhesives, however, have a low heat conductivity and the joint will lose some heat-transfer ability.

EDITOR'S NOTE: For more information on high-temperature design with oxide ceramics and sintered carbides, see the following articles:

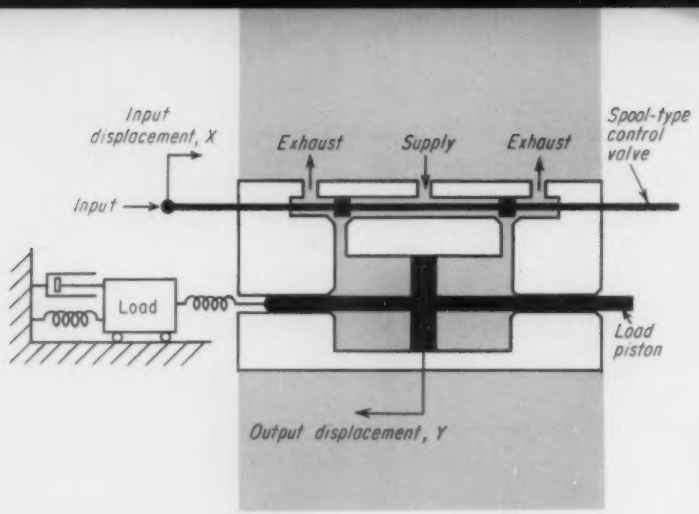
Titanium Carbide, Nov 11 '57, p 84—How to solve high-temperature problems with titanium carbide's hot strength and hardness.

Ceramics That Bounce, Feb 3 '58, p 76—Fired into spring form, sintered alumina provides elastic action at high temperatures.

Glass and Ceramic Fibers, July 7 '58, p 70—Design data on the three most important types of thread-like material with rugged properties.

New Low-expansion Ceramic, Sep 30 '57, p 70—Compares ceramics for resistance to thermal shock, gives tips on fabrication, design and applications.

Nitride-bonded Silicon Carbide, Feb '57, p 135—Man-made material bonded with silicon nitride yields parts with remarkable resistance to heat, abrasion and corrosion.



HOT-GAS VALVE operates on air at 1000 F, driving load piston (typical response characteristics on facing page). Control spools are each "underlapped" 0.02 in. at inlet and outlet, indicated by beveled ports.

TOO HOT FOR HYDRAULICS?

TRY PNEUMATICS FOR HIGH-TEMP SYSTEMS . . .

. . . say two researchers at Battelle Memorial Institute—John W. Billheimer and John K. Wetherbee. They studied a hypothetical hot-gas servovalve, to determine how air responds in fluid systems at high temperatures. This article is based on their report.

Ordinarily, air is easily compressed, so it has little value in fluid systems for power or control applications where "stiff" response is necessary. Instead, hydraulic fluids, which are relatively incompressible, are almost always used.

But this objection applies only to air at low pressures. When its pressure reaches thousands of psi, air has high bulk modulus, and can compete with hydraulics in speed of response at temperatures above 275 F, where most commercial fluids are unsuitable.

AIR WITHSTANDS HEAT

At high temperatures, hydraulic fluids suffer marked decrease in such vital properties as lubricity, viscosity and bulk modulus. Their effective values change as much as 20,000 to 1 before 1000 F is reached, and permanent damage usually results. Even special organic fluids, designed for temperatures up to 700 F, undergo drastic decline in properties at such heat. Of course, a lot depends on time at temperature.

Air, however, is relatively unaffected by temperature, and is therefore the most practical medium for fluid power and control systems at extremely high temperatures. Its bulk modulus, lubricity and viscosity are equal to or better there than the theoretical values for hydraulic fluids.

Storage of air and maintenance of system are simpler than for some special high-temperature liquids, because

air is nontoxic, and relatively easy to contain. Furthermore, its low density makes it easier to filter. One disadvantage of air is the more serious danger resulting if a large leak develops or a container bursts—the explosive expansion down to atmospheric pressure involves large amounts of energy.

SERVO SHOWS HOW AIR WORKS

Battelle's recent study of a hypothetical gas servovalve shows how air performs at high temperature. The 4-way valve sketched on facing page controls air (or gas) flow to a pneumatic piston (ram) spring-coupled to a load as indicated. Performance of this open-loop valve-ram-load system was simulated on an analog computer. Source temperature and pressure were varied; data plotted (right) are for 1000 F only. Both sinusoidal and step-input signals were simulated during the study, but the curves are for step-input only.

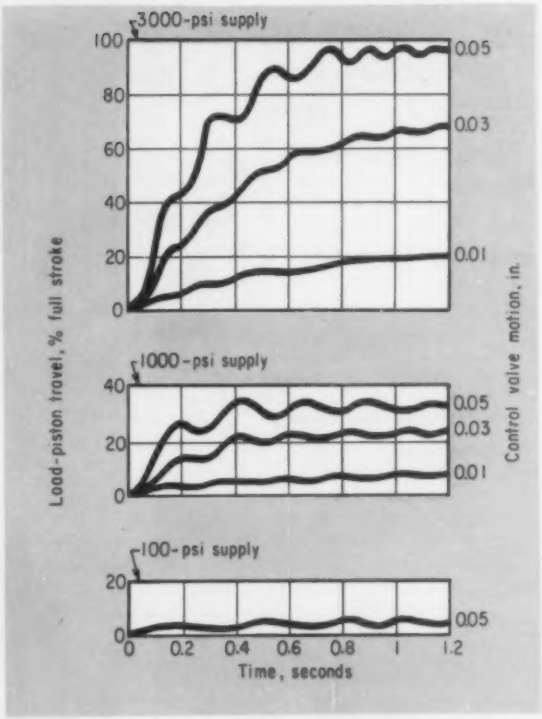
An increase in source pressure gives increased "gain" (output vs input movement), faster response, better damping, and a frequency of oscillation that rises above natural frequency of load, resulting in better control. Other data (not plotted) show that higher temperatures—even those far above 1000 F—can improve performance of such a servo, but to a lesser extent than pressure.

Hot-gas servos have been used for several years in missiles, and although the designs are proprietary, they resemble the sketch. Basically, all systems have a constant-pressure source of gas controlled by a servovalve positioned by an electronic amplifier and torque motor. Valve may be open- or closed-center type (orifice nozzles constantly open; or closed until servo is to be actuated). Final element is a feedback loop that sends signal from output piston to input amplifier.

PNEUMATIC AMPLIFIERS

Electromagnetic devices normally used for amplifying and controlling output and input signals are not reliable at extremely high temperatures, and much development work has been done on nonelectrical amplifiers and control elements. One such is the fluid amplifier developed at the Army's Diamond Ordnance Fuze Lab (*PE*–Mar 14, '60, p 17). It works on gas (or liquid), and consists solely of a block of metal (or ceramic) in which fluid passageways have been strategically placed.

Principle of operation is simply the deflection of a high-power stream of gas by a low-power stream at right angles to it. In effect, the high-power stream is "aimed" by the low. Useful temperature can be extremely high—it is limited only by the metal or ceramic chosen. Speed of response of a pneumatic amplifier is slower than that of an electronic version; it is roughly in the ratio of the speed of sound to the speed of light. Power amplification can be about 100:1. This fluid amplifier, however, is still in the research stage and is not available as a control component.



LOAD-PISTON MOVEMENT for hypothetical 1000-F pneumatic servo on previous page depends on supply pressure and control-valve position. Against a given load, higher source pressure results in more output movement for given input. Input here is step-function type, in which spool is moved suddenly from center to given position X. All data were from simulated operation on analog computer.

EDITOR'S NOTE: High-temperature and high-pressure fluids and devices have been the subject of these previous articles:

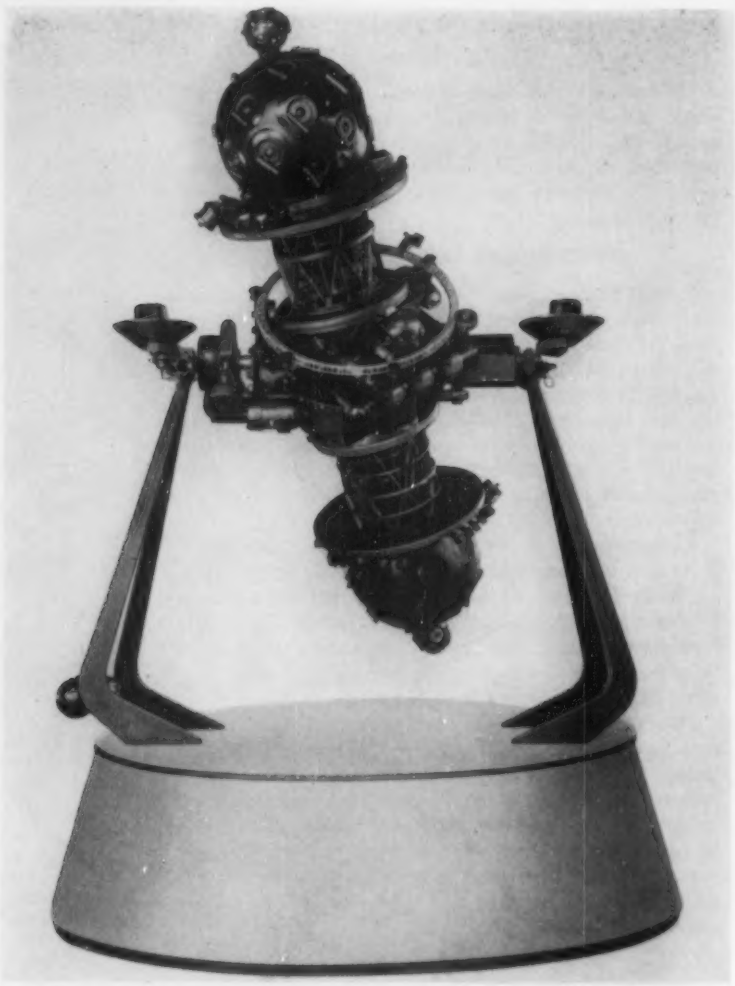
Modern Fluids for Power and Control, Jan 18 '60, p 56—Design data on most hydraulic fluids, including petroleum, silicones and glycol, giving viscosity, bulk modulus, solubility and compatability up to 200 or 300 F.

New Data for High-pressure Air, Sep 14 '59, p 71—Up-to-date summary of air properties up to 5000 psi, from —100 to 250 F, based on Amsterdam Institute research. Graphs are designed for quick reference.

High-pressure Pneumatic Circuits for Aircraft, Mid-Oct '55 p J-26—Discusses storage and system-design problems.

High-temperature Electrical Equipment, Sep 26, 60, p 56—Describes developments in motors and solenoids that can operate at 1000 F.

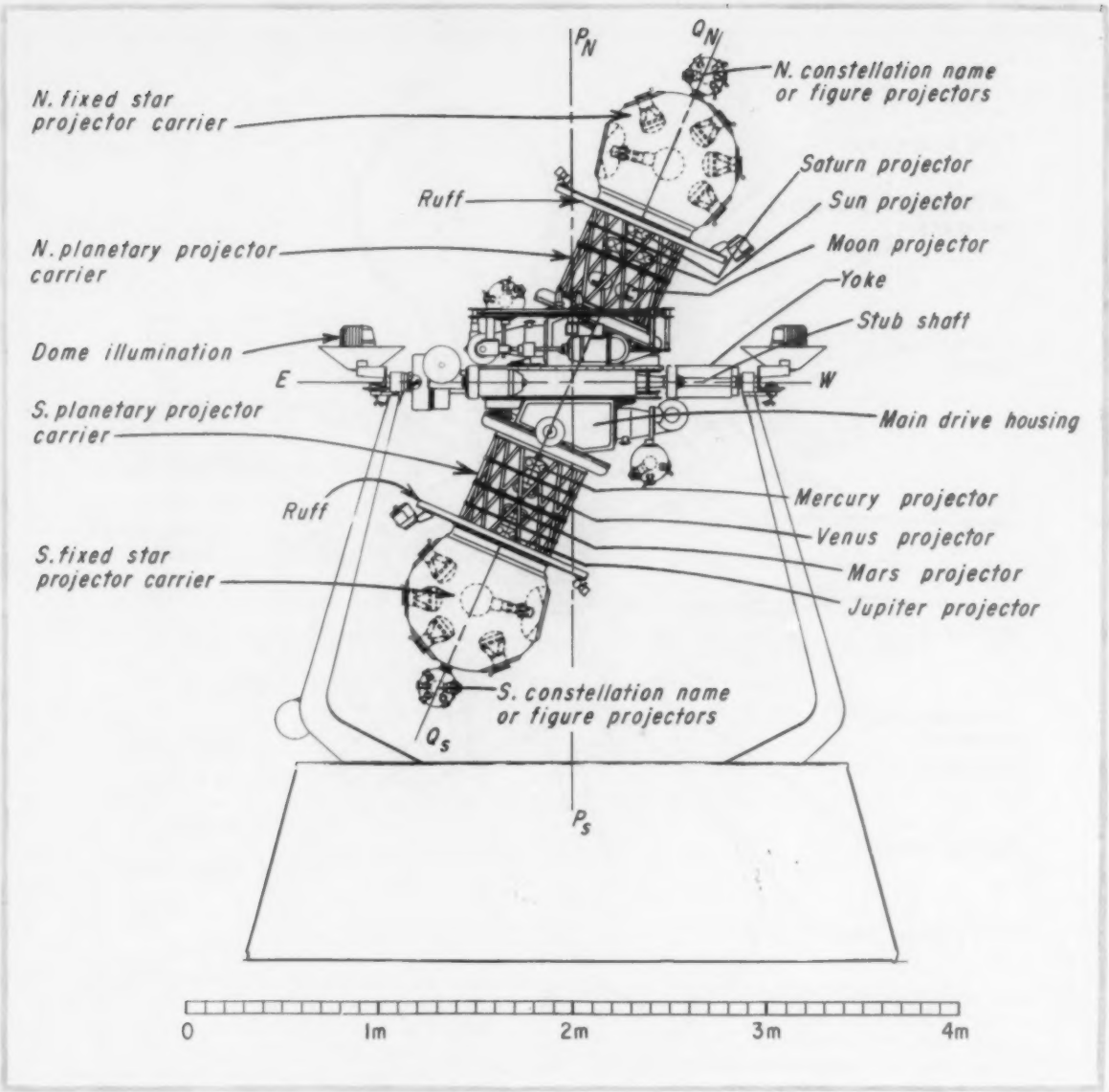
Look for article in coming issue on unusual hydraulic fluids designed for 500 F and higher. Included are liquid metals and salts.



Newer Way to Put Stars Through Their Paces

Latest-design projector at Hayden Planetarium shows all celestial objects visible to the naked eye in position corresponding to any date and latitude. Positional error is less than 1° in the equivalent of 100,000 years.

PS . . . On inside of its dome the planetarium realistically represents the sun, moon, planets and 8900 stars. Gear trains and motors are interconnected to recreate exact diurnal (daily) and annual movement of the earth as well as precessional rotation (movement of earth's axis relative to positions of the fixed stars). Allowing for precessional motion, which occurs at rate of one revolution every 25,800 years, requires gear reduction of 156,000,000,000 to 1. This new projector weighs 2½ tons and rises approximately 17 feet above the floor. It was installed at the American Museum's Hayden Planetarium, NYC, by its designers and constructors, Carl Zeiss, Oberkochen, Wuertt, W Germany.



DUMBBELL-SHAPE INSTRUMENT has spherical end pieces that house the fixed-star projectors. The latticework sections connecting these end pieces to the main drive contain the projectors for the sun and moon plus the planets Mercury, Venus, Mars, Jupiter and Saturn. This latticework provides rigidity with light weight and presents minimum obstruction to light rays from planet-projectors.

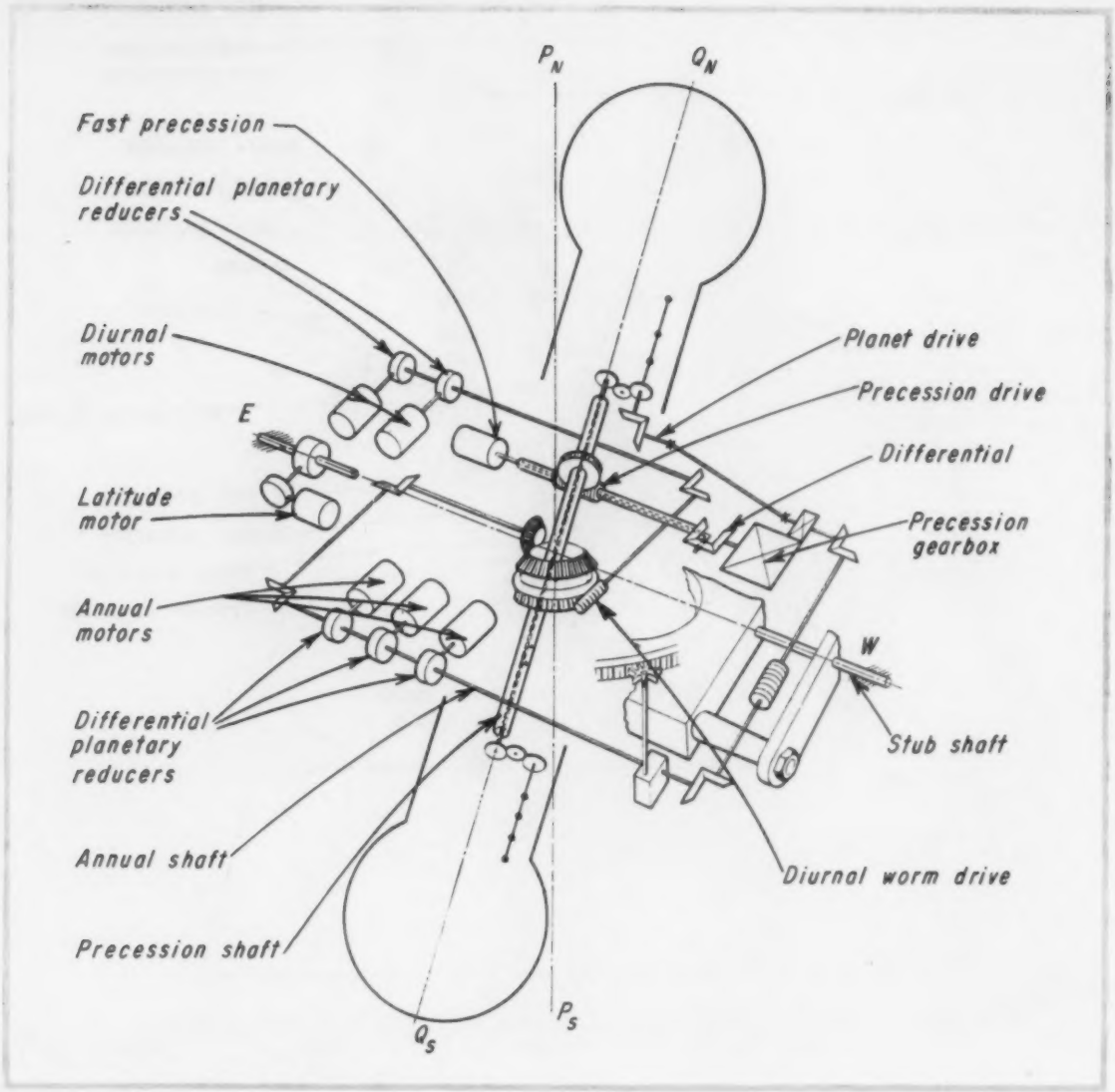
. . . The polar axis of the instrument, P_n-P_s, represents the north-south axis about which the earth rotates daily. By tilting around the east-west axis, E-W, which is horizontal, the geographical latitude can be altered as required. With P_n-P_s axis horizontal, the star pattern represents the view seen by an observer at the equator.

. . . The main axis of the instrument, Q_n-Q_s, is 23½° from the north-south axis, P_n-P_s. This axis Q_n-Q_s represents the ecliptic, whose direction is perpendicular to the plane described by the orbit of the earth around the sun.

. . . Stub shafts fixed to the frame rotate in the yoke around the east-west axis E-W. The entire instrument may be rotated around this axis in 6.5 min. The main drive housings are mounted on ballbearing rings and interconnected through the yoke.

. . . The drive mechanism produces daily rotation of the earth about polar axis P_n-P_s and yearly rotation around ecliptic axis Q_n-Q_s, plus extremely slow precessional rotation (once every 25,800 years), provided by a series of drive motors. These motions are carried out at a greatly accelerated rate (diurnal rotation in 4 min.) but with the exact interrelation that occurs in the movement of the planets. The gearing which connects these movements is permanently meshed to maintain the correct settings; no clutches or slip couplings that could be disconnected are used.

The small spherical housings at each end of the instrument project the names or the outlines of the familiar constellations. The two "ruffs" are used to mount and house the projectors for the brightest stars plus three variable stars.



PROJECTOR MOVEMENT is controlled by a series of 1/6-hp, three-phase motors running at a constant speed of 1380 fpm. The diurnal and annual movements are produced by operating two or three motors either forward or reverse. These operating combinations are made possible by the use of differential planetary reducers.

. . . **Diurnal motion** around the axis P_S-P_s is provided by two motors driving through reducers, right-angle drives and the diurnal worm and wheel. Depending upon the motor used, a complete rotation equivalent to a full day can be made in 12 or 4 min. Running both motors together, or one forward and one reverse, results in speeds of 3 or 6 min. per rotation.

. . . **Annual motion** about the axis of the ecliptic Q_S-Q_s may be combined with diurnal motion. To simplify observation of the revolution of the planets, the annual motion may be run independently. Run singly, the annual motors permit one year to be represented in time intervals of 12 min., 4 min., or 11 sec. In combination the three motors can cover one year in 6 min., 3 min., or 10 sec.

. . . **Precessional movement** of the earth's axis is superimposed when the annual and diurnal motions are combined.

This motion is opposite to the earth's rotation about the sun and requires 25,800 years to complete. This precessional motion is demonstrated by rotating the instrument around the ecliptic axis Q_N-Q_n. The precession drive is powered by the annual motor through a gearbox and differential. A fast precession motor has been provided because the normal precession movement is too slow for demonstration purposes. Driving the arm of an intermediate gear in the differential, the fast precession motor completes one rotation in 4 min.

Planetary projector movement is provided by a shaft running from the precessional gearbox to the north latticework structure in which the projectors are mounted. This shaft powers the projector drive for the moon, sun and Saturn. Motion is transmitted to the southern half of instrument through a shaft and gearing. The southern latticework supports the projectors for Jupiter, Mars, Venus and Mercury.

CREATIVITY TESTS ARE HELPFUL

■ *In our Feb 22 issue, Dr Donald A. Schon of Arthur D Little Inc made a sharp attack: "These tests rest on certain false assumptions which make them ineffective and in some cases downright harmful." ■ Here's rebuttal by the men who designed, validated and used one of the creativity tests most severely criticized by Dr Schon* ■

ALVIN L SIMBERG
Supervisor of personnel research & development, A C Spark Plug Div
Dr RICHARD H HARRIS
Director of employe research, General Motors Corp

No one pretends that psychological testing is the complete answer to personnel selection; and few responsible companies makes selections solely on the basis of psychological tests. Actually the more responsible the company the fuller use it will make of *all* the measures of a man's suitability for a particular position.

But certainly every responsible company will attempt to improve its selection procedures, and carefully controlled studies suggest that some of the newest psychological and technological concepts show considerable promise.

What we are after is an instrument or tool that will give a supervisor some estimate of the creative ability of his staff—an estimate that can be used independently of job performance as a check and as a predictor of performance.

The *AC Test of Creative Ability* was an original work by the authors. It was based in part on earlier research by Prof J. P. Guilford of the University of Southern California. He had investigated the different factors involved in creativity and tried to measure them. The factors he isolated were: fluency, flexibility, ability to change set, ability to visualize new uses for common objects and, finally, a certain discontent with things as they are. Later studies have proved that the AC test can reliably differentiate individuals considered creative by their supervisors from those who are not.

Definitions Are No Problem

The most frequent objections to tests of creativity are that creativity has not been adequately defined, that the characteristics of creative men are unknown or unknowable, and that there are "different types" of creativity. All these are, in fact, quite academic and of little practical significance. Whenever we have set up an experiment and asked supervisors about creativity they were in substantial agreement on which men are or are not creative. As with intelligence, or the force of gravity, we all know what the characteristics are, even if we don't know precisely what causes them.

Our test was designed as an indicator of a person's ability to produce a number of unique ideas for a given situation in a given amount of time. The result is not an absolute measure of creativity but a relative ranking of the individual in his own company group.

In our company, we have established separate norms

for engineers, supervisory personnel, and hourly rated personnel. We have found statistically valid differences in range and test scores for these groups.

The Test Itself

The test is in five parts. Each part is separately timed and the total working time is 80 minutes. There are no multiple-choice or true-false questions. Each answer must be created in the imagination of the person taking the test. Here is an example of each type:

1—In a thick fog in a major American harbor, a passenger liner moves cautiously toward its berth. The liner has the latest radar equipment, but the equipment is inoperative and the radar operator is unaware of this fact. Another boat approaches the liner amidships, and it is obvious that neither ship is aware of the other's presence. List all the things you think might happen as a consequence.

This test contains five such situations. You list as many possible consequences of each situation as you can. Scores are a function of quantity and a uniqueness of the imagined consequences. (20 min.)

2—List as many reasons as possible to explain the truth of this statement: Residents of Chicago consume, on the average, more Brazil nuts than residents of Omaha.

This is a test of general reasoning. Five unusual and not necessarily true statements are presented. You must marshal your arguments to make them seem reasonable. This part also yields a quantity and a uniqueness score. (10 min.)

3—List all the things you think are wrong with, or could be improved upon, in a wrist watch.

A test of awareness of the problems in five common appliances. This part yields a uniqueness score. (15 min.)

4—An Air Force pilot is told to take samples of air at five different altitudes up to 10,000 feet. For this purpose he is given a small plane with a nonpressurized cabin and five bottles with small openings that can be sealed with a cork. When he is ready to take off, it occurs to him that the bottles already contain ground-level air. This air has to be removed so that air at the varying altitudes can be collected. Rather than go to the trouble of locating a pump or other special device to create a vacuum in each bottle, how can he accomplish the assigned task?

This is a test of practical judgment. The five problem situations call for solutions that are least expensive and least time-consuming. This part yields a quality score. (20 min.)

5—How many uses can you think of for a common paper clip?

This is a test of originality. The five common objects yield both a quantity and a uniqueness score. (15 min.)

Scoring

The test produces three types of scores: Quantity (in Parts 1, 2, 5), Uniqueness (1, 2, 3, 5) and Quality (4). The measure of uniqueness is derived from a statistical tabulation—answers given infrequently get more points than the more common answers. Quality of a solution (in Part 4) is measured against a scale set by a panel of judges. The judges award highest scores to the least expensive and least time-consuming solution.

As you can see, though the test measures flexibility, fluency, problem sensitivity, and so on, imagination is still the prime requisite for a high score.

The Results

We insisted on two requirements for anyone wishing to use this test. The user first had to send someone to our offices to learn all aspects of administration, scoring and interpretation. Then a validation study had to be made, consisting of testing carefully selected groups within the user's company. These restrictions were not for our own benefit but rather to help the organization wishing to use the test—one might almost say for its protection. In this way we have a growing mass of data on the performance of the test itself plus a set of representative norms against which individual scores may be measured.

The original validation study was conducted on 36 engineers from two divisions of our company. Half of the 36 engineers had been rated by their supervisors as consistently producing many unique ideas; the others had rarely produced ideas of any kind. We found that the test differentiated between the two groups at the 1% level of statistical significance.

A second group of 35 engineers was selected, consisting of an entire design and development department. Superintendent and assistant superintendent had independently judged the individual's performance on creative tasks. Of the group, 22 were reported as consistently satisfactory, while the performance of the remaining 13 in this respect had, at one time or another, been unsatisfactory.

The difference in scores was remarkable. Individual scores varied from under 1000 to over 6000 but the mean of the low group was about 2200 while the mean of the high group was over 3500. So large a difference in means, combined with the relatively close clustering of the scores in each group around its mean, could not have been obtained by chance in more than one case out of one hundred. Thus the test again differentiated between two groups at the 1% significance level.

Thus far, we had been correlating the tests with ratings or opinions of superiors. A third study was then conducted, using the number of suggestions turned in by hourly rated employes as an objective measure of creativity. The study involved 28 pairs of individuals. Each pair had one man with an outstanding suggestion record and one with a poor suggestion record. Each pair was matched as nearly as possible—both men in the pair were from the same department, with the same supervisor, the same job classification and equivalent seniority. It was found that the quantity scores on the test were again related at the 1% level to the number of suggestions turned in by these people.

Still other types of criteria were sought. At MIT, 45

senior engineering students enrolled in a product design course were given the test. This course strongly emphasized imagination because of the nature of the material covered and the projects assigned. The instructor, Prof John Arnold, did not see the test results until after final grades had been assigned. The differences on test scores between students earning grades of A and students earning grades of B were again significant beyond the 1% level. In addition, the instructor had made subjective comments about the observed creative ability of each student. These were based upon his observation of their methods, questions and performance during the semester. Again, the test found differences closely associated with his comments.

The *AC Test of Creative Ability* has been tried in many divisions of General Motors Corporation as well as in many companies outside of General Motors. Complete validation studies have been undertaken at Underwood Corp, Dow Chemical, Smith-Kline-French, etc. All results were positive and significant. In other words, the test successfully differentiated between groups of people considered creative and not creative.

Everyone is looking for the man with ideas. It really does not matter so much whether he searches his own experience for ideas or whether he solves his problems piecemeal or whether he uses analogies. What is important, and most often overlooked, is that in all of these approaches he is using his imagination and developing ideas. If you can find a person who has ideas, and who is not reluctant to give them, you can infer that he would be a better risk than someone who does not demonstrate this ability. The *AC Test of Creative Ability* purports to measure the number of unique ideas which an individual can develop for a given situation.

Try It Yourself

We have no intention of making a profit out of this test and so it was offered to the Industrial Relations Center, University of Chicago, which is now making it available to interested users. This nonprofit organization is observing the cautions stated above and requests careful consideration before the test is used. The charges only cover printing costs.

The Other Criteria

Let us repeat, tests should never be used as the sole determinant in making personnel decisions. The employment interview can yield excellent indicators of interest, personality, maturity and appearance. A thorough interviewer will pay careful attention to references—the types of people listed and what they say. Former employers can help corroborate what the references say about honesty, stability, dependability and other character traits. Resumes of education and experience are also useful in assessing an individual.

When a man is considered for promotion, job-performance appraisals are excellent. They may show how he gets along with others in the department, how well he does his job, whether he assumes responsibilities. These are all questions which the new supervisor would want to know. In some cases, a job tryout is possible; this is a chance to watch the individual perform different functions.

All these techniques and others can yield information that no test yet devised can duplicate. The tests, on the other hand, can give information extremely difficult to obtain from other sources. Each source complements the other and no effort is made to say that one or another of the sources is most important. No responsible manufacturing manager would deliberately avoid using modern tooling. No competent engineer would refuse to consider new materials that have unusual, useful properties or characteristics. It certainly follows that no responsible personnel manager would avoid using one other technique or tool, such as a creativity test, if he first proves to himself that it can help him select more creative employes.

EDITOR'S NOTE: For more on creativity and pre-employment tests for engineers, see:

Are Creativity Tests Helpful? Feb 22 '60, p 37. This is the article that started the debate. Management's intensified interest in creativity has brought a number of types of tests into vogue. They take various approaches, disagree on what variables measure creative performance. Author suggests they may be more for tester than testee.

How Good Are Engineering Aptitude Tests, Nov 30 '59, p 32. A report, compiled from testing agencies and personnel departments, describing advantages and limitations of ability tests and other psychological exams. Included are examples of typical engineering tests.

Creativity . . . the Facts Behind the Fad. Aug 24 '59, p 20. A summary of information brought to light at a 3-day Harvard conference on creativity.

Are You Creative? Nov 17 '58, p 28. A psychologist lists traits, both social and personal, common to most creative people . . . his wife illuminates each trait with a personal note.

Research Management . . . a Problem in Personalities, Sep 8 '58, p 30. A description of typical research personality types, and suggestions for the kind of incentives that appeal to each.

Individual Invention — a Lost Art, Feb 24 '58, p 33. The inventor of the process used for producing titanium and zirconium claims that individual thought is a valuable resource.

Lone Invention—No Lost Art, June 2 '58, p 26. Individuality need not be hostile; cooperation between creative people is possible without sacrificing originality or independence.

Can You Spot a Creative Engineer? June 16 '58, p 30. A checklist of unusual attributes of creative people, suggesting that creativity doesn't necessarily wear a tweed jacket and smoke a pipe.

Organization and the Human Being, Dec 30 '57, p 26. Formal organization of large corporations results in conflict and tension, stifling creativity. Here are the grievances and a list of remedies.

Interviewing Engineering Job Applicants, July '55, p 158. Suggested preplanned interviews in which the applicant's response can be interpreted to give a clear indication of his engineering ability.

HOW THE RESISTANCE TRANSDUCERS compare

When a control system needs an electrical signal responding to a change in position or displacement, these devices offer a varied combination of range, sensitivity and linearity.

J R McDERMOTT
Electronics consultant
McDermott Associates

Resistance transducers transform mechanical motion into an electrical signal, with the magnitude of the signal dependent on the displacement. Change of resistance results from changing the active area or length of the conductor. This is done by either linear or rotary displacement.

POTENTIOMETER

Simplest form of potentiometer transducer is a straight resistance wire or ribbon with a sliding contact. Resolution is infinite and motion may be linear or rotary. One limitation of this type is its low resistance, seldom more than 10 ohms. For higher resistance, the wire is wound around a core, and resolution is limited to the resistance of a single turn. For rotary displacement this construction is a standard potentiometer.

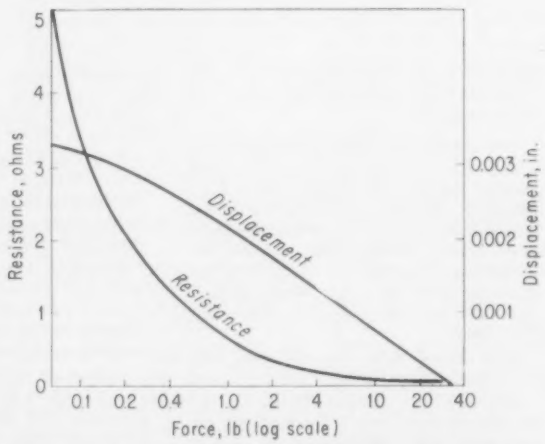
Linear travel is usually limited to a few inches, but lengths up to 30 in. or more can be provided. Rotary potentiometers are available for a single rotation of less than 360°, or some multiple–10 full turns for a common type, or as high as 40 turns.

In some applications, the potentiometer output can be applied directly to provide an indication or control. However, it is sensitive to loading, particularly in the higher range of resistance. This effect distorts the output function. Amplifiers may be used to overcome this limitation in the use of potentiometers.

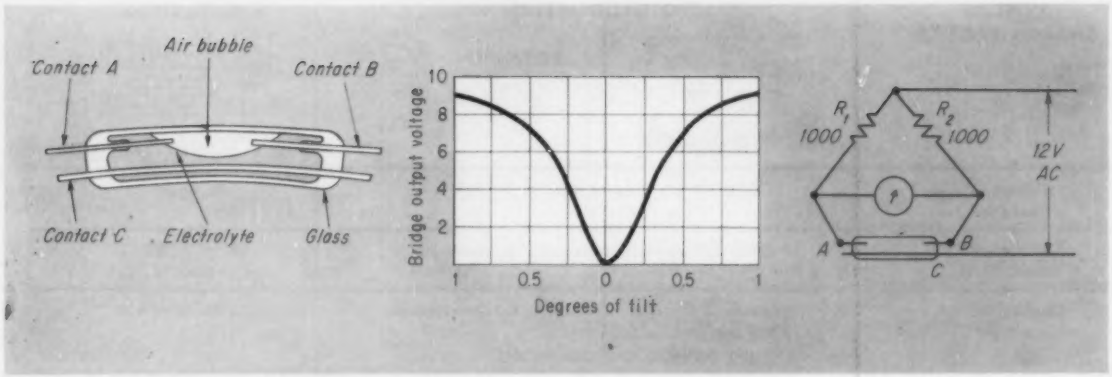
STRAIN GAGE

This type of transducer consists of a grid of fine wire or a thin conducting pattern, in the order of a few thousandths of an inch or less. When this grid is subjected to strain, the wire increases in length and decreases in cross-section, producing a change in resistance proportional to strain or displacement.

Maximum change in resistance is about 1%, and because output is low–in millivolts–it requires amplification. It is invariably connected for operation in a bridge-type circuit. The output voltage can be increased by using a higher bridge-excitation voltage, but because of the fine wire, this is limited by the danger of overheating the wire and damaging the gage. Individual gages vary in resistance depending upon the application and gage type–usually between 50 and about 5000 ohms.



Carbon pile is a highly nonlinear transducer. Highest sensitivity to change in force is at light loads, and minimum range usually is limited by stability of response.



Electrolytic transducer made by Hamlin Inc, based on the common spirit level, is highly sensitive to small displacement from its null or center positions when used with a bridge circuit. Bridge must be energized with ac to avoid effects of polarization on electrodes. The unit requires a level platform, and is most effective as a null device.

CARBON PILE

One of the oldest forms, the carbon pile consists of a stack of thin, flat carbon disks mounted between a fixed and a movable electrode or support. When a force is applied to the stack and the carbon disks are compressed against each other, resistance of the stack decreases.

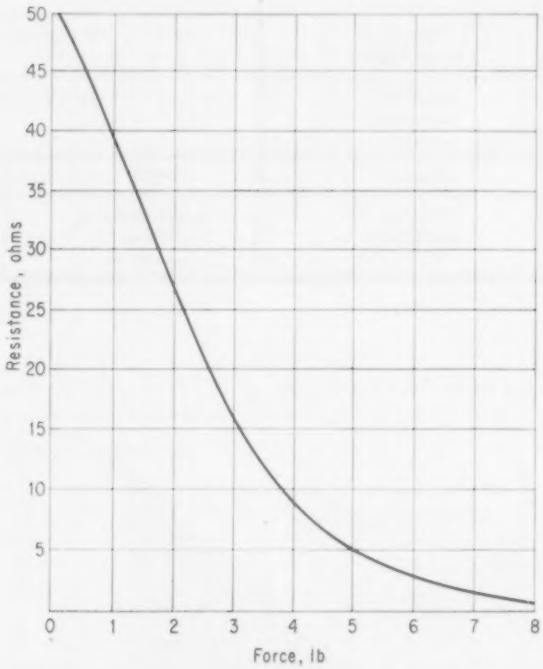
Resistance variation is smooth and continuous but nonlinear and sensitive to temperature. A linear output can be approached by using two piles in a resistance-bridge circuit, and applying the force to one while reducing it against the second. This bridge connection also minimizes the influence of resistance change from heating.

Change in resistance takes place at the interface between the disks, and not inside each wafer. At light loads (high resistance value) external vibration can produce hysteresis and drift in resistance. For most applications it is necessary to limit the higher resistance value by preloading.

ELECTROLYTIC

The resistance between two electrodes in an electrolyte depends on the electrolyte and shape of the conducting path. Changing cross-section or length of the path varies the resistance. An example is a transducer using this principle which has recently been developed by Hamlin Inc for measurement of small angles. Essentially, the device is a bubble level with a common electrode always immersed and separate electrodes extending into the bubble from each end. When connected in a bridge circuit, tilting of the device increases the resistance in one leg and decreases it in the other. The change is relatively linear.

At the center position is a small null potential—in the order of 10 millivolts for usual bridge applications. The rate of change in signal with rotation is maximum at the centerpoint, and the device is sensitive to 1 min. of arc. Power output is limited by heat dissipation, and also by bubbling at the contacts, which decreases stability of the null point. It has a relatively large variation of resistance with temperature, but when used in a bridge circuit this only changes the magnitude of the signal and does not affect the location of the null point. To avoid polarization effects, ac excitation is used.

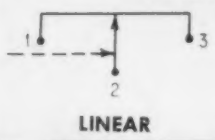
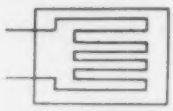


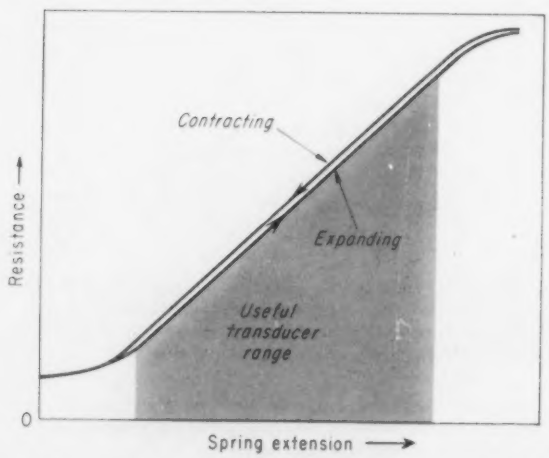
Pressure cells made by Clark Electronic Lab, using a conducting resin as the sensing element, have essentially a linear response at light loads—with decreasing sensitivity as load increases.

PRESSURE CELL

Certain intermetallic resins change resistance when compressed, providing a solid-state transducer suitable for force measurement. Typical form, as produced by Clark Elec-

BASIC TYPES OF

TYPICAL CHARACTERISTICS	POTENTIOMETERS		STRAIN GAGE
	 LINEAR	ROTARY	
Excitation voltage	Ac or dc		Ac or dc
Resistance range, ohms	Ohms to megohms, depending on winding		50 to 5000
Displacement range	Normally 2 or 3 in.; can be made any length	Up to 40 revolutions	0.003 in. max
Actuating force	0.005 to 10 oz-in.		0.2 to 100 oz
Output	Depends on applied excitation voltage		0.010 to 0.045 volts
Type of Circuit Used	Voltage divider		Bridge
Auxiliary equipment required	Amplifiers may be used		Amplifiers
Accuracy	1%	1%	0.1%
Typical application	Measurement of linear displacement	Measurement of angular displacement	Load cell, strain measurements



Variable-pitch spring has a closely linear response with some directional hysteresis. Sensitivity varies with resistivity and diameter of the spring material; range varies with length of spring wire.

tronic Lab, is a resin pellet bonded to a recess in a brass or stainless steel holder.

These cells have a relatively wide change of resistance. Load depends on the composition of the resin, ranging about 15:1 for cells with resistance in the order of ohms, to a change as high as 3,000,000 to 1 for cells with a maximum resistance of 100 megohms or more. Highest sensitivity is at lighter loads where response is nearly linear; resistance change becomes nonlinear with increasing loads.

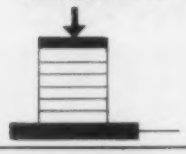
High outputs are obtained directly; a unit rated at 30 ohms minimum change, on 6 volts dc conducts less than 0.2 amp at no load; at rated load of 2 lb, the cell resistance decreases to conduct a current of 3 amps.

These cells are essentially a pure resistance, and can be used with relatively high-frequency currents, limited by capacitance between the cell contacts. Cells are sensitive to high temperature (over 500 F), which decreases sensitivity and limits the power they can handle to about 10 watts, although special units have been designed for higher dissipation.

VARIABLE-PITCH SPRING

One useful but not too well known form of resistance transducer is a variable-pitch tension spring. It may be

RESISTANCE TRANSDUCERS

CARBON PILE	ELECTROLYTIC CELL	PRESSURE CELL	SPRING
			
Ac or dc	Ac	Ac or dc	Ac or dc
0.015 to 2.5 min 0.30 to 60 max	Depends on electrolyte	500 min 100 megohms max	Closed, 0.1 to 5; open, 3 to 20
0.006 to 0.018 in.	Depends on application	0.0005 in. min 0.007 in. max	0.0001 to 0.6 in.
1 oz to 32 lb	Low	0 to 4 oz min; up to 40,000 psi max	0.03 to 5 oz
Depends on applied voltage	Depends on electrolyte and applied voltage	Millivolts to over 100 volts, depending on cell rating	Depends on applied voltage
Series or bridge	Bridge	Series or bridge	Series or bridge
None	None	None	None
5%	1%	½% (see note)	1% to 2%
Noncritical control of voltage or current	Measurement of angular displacement	Load cell, solid-state contactor	Measurement of linear displacement

NOTE: This value is for low-resistance cells; higher resistance cells are less accurate

wound with varying initial tension over its length, or formed with varying coil diameter, or wound with wire having a uniformly decreasing cross-section.

With no load, all coils make contact with each other, and resistance is a minimum. When the force is applied, turns gradually separate, increasing the resistance at an essentially linear rate.

These spring transducers can be made of high-strength noble metals or steel, gold-plated for better contact. Wire diameters used range from 0.005 to 0.015 in.; minimum resistance values are 0.1 to 5 ohms. For gold-plated steel springs, the ratio of maximum to minimum resistance may be as high as 50 to 1.

For operation over short periods of time, error is only 1 or 2%; over short ranges of operation—0.001 to 0.01 in.—deviation can be maintained within 2%. Linear range may be expanded by using the springs in matched pairs in a resistance bridge.

SEMICONDUCTOR

A new line of solid-state pressure transducers was recently announced by Fairchild Controls Corporation. This sensitive element consists of several microminiature, piezoresistive, semiconductor elements coupled to a resilient, low-mass, alloy steel diaphragm and connected in a conventional four-arm bridge. Applied pressure deflects the diaphragm and produces a signal proportional to the deflection. Nominal excitation voltage is 10 to 25 volts dc; at 20 volts, a full change in pressure produces an output of 5 volts. These units are incorporated in pressure gages with full-scale values ranging from 100 to 10,000 psi; still lower ranges are under development.

EDITOR'S NOTE: For additional information on force sensors, see:

Better Accelerometers off the Shelf, Sep 5 '60, p 54—Describes and compares six types of accelerometers used in testing, speed control, remote leveling, and balancing.

Piezoelectric Transducers Measure Fluctuating Forces, Pressures, Accelerations, Apr 27 '59, p 61—How piezoelectric accelerometers work; their limitations and applications.

Pressure-sensitive Material Measures Explosion Forces, or Footfall of a Fly, Sep 16 '57, p 106—Properties and application data on pressure cells made from rare earths.

Three articles on application and design of strain-gage bridges:

Strain-gage Balancing Simplifies Multiple Bridge Measurements, June '56, p 161.

Strain-gage transducers, March '56, p 196.

Strain-gage bridge Sensitivity Control, Jan '56, p 200.

SILICONE NEWS from Dow Corning

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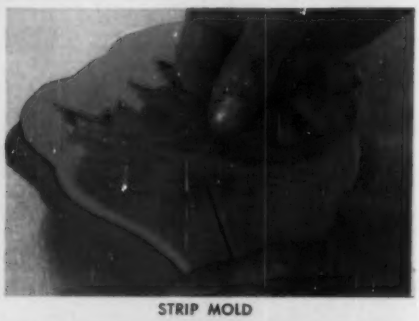

STRIP MOLD

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ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.

BEAMS:

how much torsion for OFF-CENTER LOADS?

Unsymmetrical beams twist under bending loads. Labor-saving curves for two common cross-sections locate shear center that simplifies torque calculations.

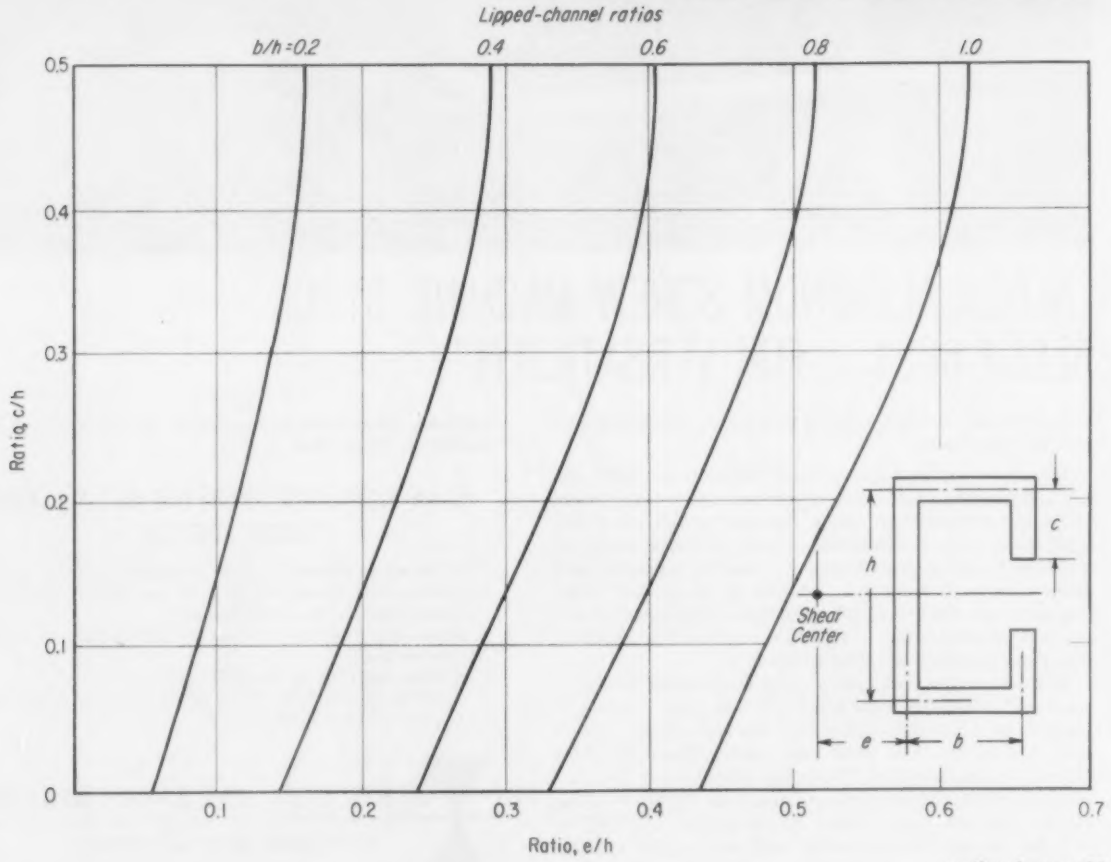
S WARREN KAYE, *Missiles Systems Div, Raytheon Co, Bedford, Mass*

When a force loading a symmetrical beam passes through the centroid, it produces pure bending. But with unsymmetrical beams the force twists the beam while bending it. To produce pure bending and no torsion the load must pass through the "shear center" of the cross-section. Knowing the location of the shear center also enables predicting how much torsion is produced by a force that does not pass through the shear center. Only then can one find stresses and deflections. The following plots locate shear center for lipped channels and hat-sections.

SYMBOLS

b = depth of channel
c = width of channel lips
e = distance of shear center along axis of symmetry
c/h = ratio with which to enter curves
b/h = ratio with which to enter curves
e/h = ratio derived from curves

Dimensions can be expressed in any unit of length.



continued, page 83

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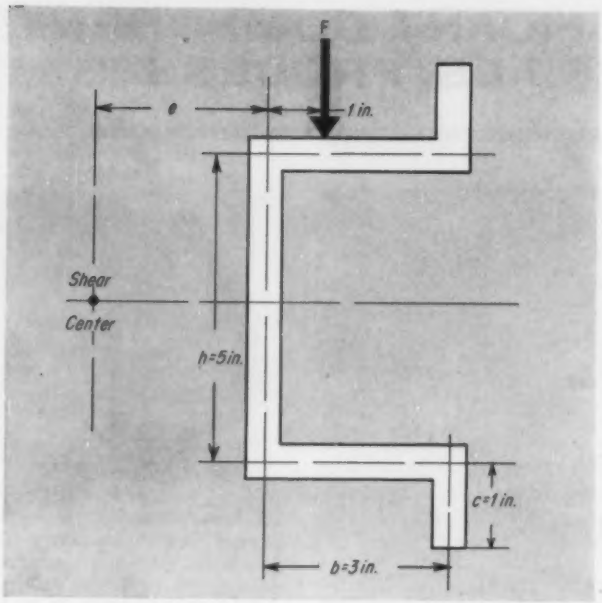
3. Extensive mill and distributor inventories to meet all requirements.
4. Chamfered ends at no extra cost.
5. Specific 12-ft lengths at no extra cost (for rounds up to 2¾ in.; hexagons up to 2 in.).

ALCOA ALUMINUM

SCREW MACHINE STOCK

OFF-CENTER LOADS continued



EXAMPLE: How much torsion will force F produce in the hat-section at left?

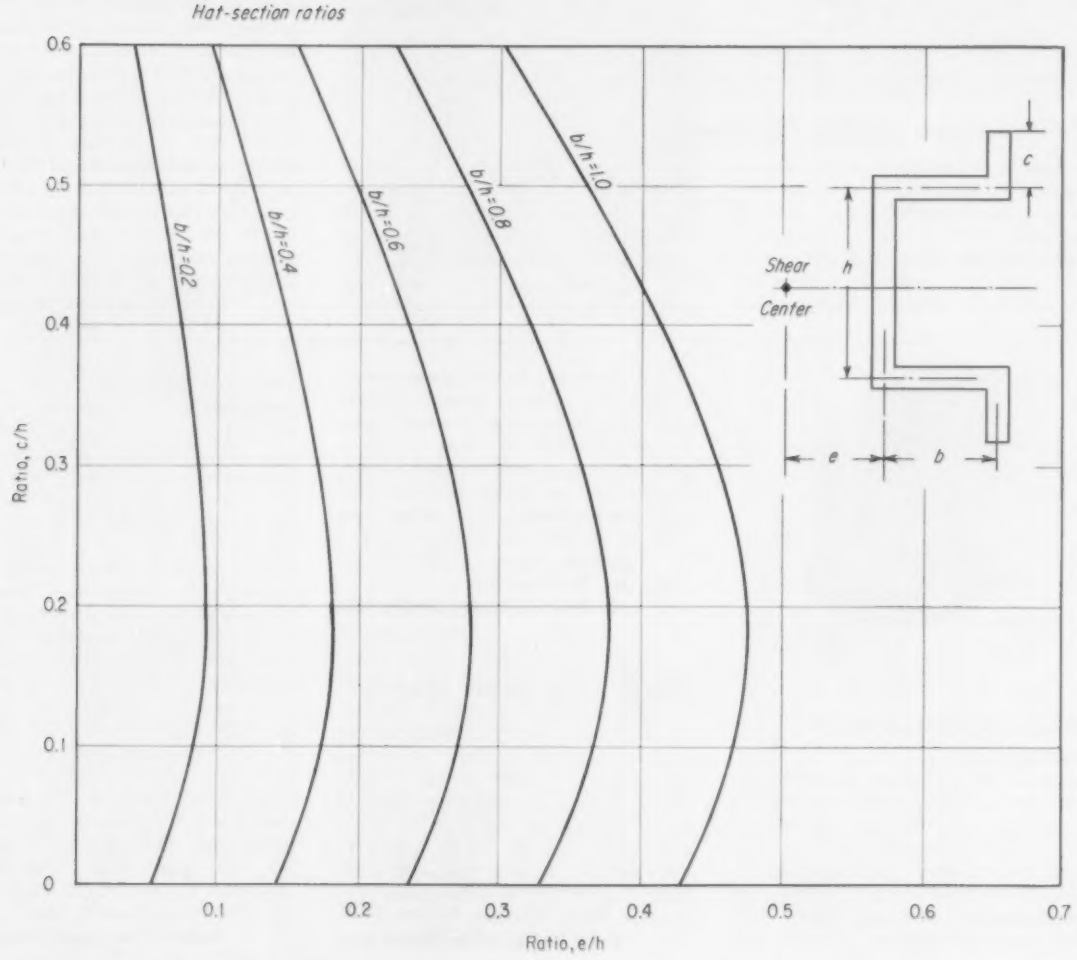
SOLUTION: Shear center is at intersection of the two shear axes. Horizontal axis coincides with the axis of symmetry. Use curve to find dimension which locates the vertical shear axis.

Ratios for the hat-section are:

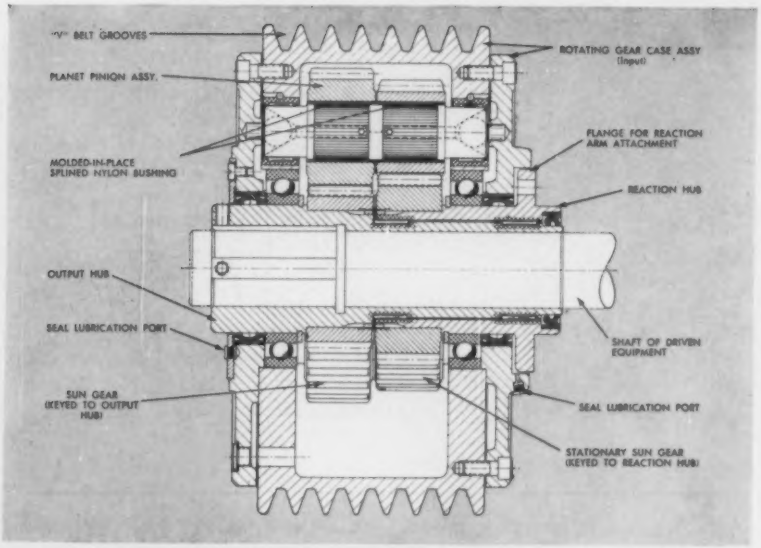
$$b/h = 3/5 = 0.6$$
$$c/h = 1/5 = 0.2$$

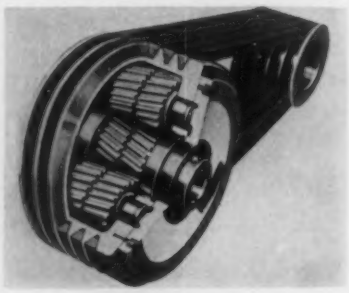
From the curve, $e/h = 0.28$

Therefore $e = 0.28h = 0.28 \times 5 = 1.40$ in. Moment arm of F about shear center is $e + 1 = 1.40 + 1 = 2.40$ in., therefore torque is 2.40 F.



SIGNIFICANT COMPONENTS MATERIALS, PROCESSES





Shaft-mounted rotating transmission . . .

is said to be one-third smaller and to provide up to six times the torque of other types of transmissions. Capable of reduction ratios up to 270:1 exclusive of additional reduction through pulley drive from drive motor, and wide range of control options for clutching, shock and overload capacity and dual-speed operation. Transmission, concentrically mounted on driven shaft, operates machine at reduced speed from that of drive motor. Entire transmission is contained within outer surface, machined for V-belt drive from motor. Basic unit is differential planetary-gear transmission. Cutaway shows internal arrangement of three-pinion assembly transmission and manner in which power from drive motor is transmitted through V-belts, which fit in grooves on rotating gear-case assembly. Through use of injected-nylon splining, transmission can incorporate as many as 12 planetary pinion assemblies, compared to two sets for conventional devices. Available in capacities from fhp through 60 hp, for torque ratings through 21,850 ft-lb in standard models with double planetary gear sets of two to six gears. Priced from about $110 to $4000 for units with max output torque of 115 to 21,850 ft-lb. Delivery time, about 6 wk. **Airborne Accessories Corp, Industrial Div, 1414 Chestnut Ave, Hillside 5, NJ.**

Circle 300 on Reader Service Card

Thermohardened beech veneers . . .

and solid beech blocks are densified under great heat and high pressure to form oil-resistant material with even hardness and low moisture absorption. Said to have high wear and abrasive resistance; impact-, bending- and tensile-strength; resilience and mechanical and dimensional stability. Solid and laminated types are available with density ranges of 1 to 1.38 specific gravity. Cross-bonded veneer laminate utilizes phenolformaldehyde as bonding agent. Available as sheets or blocks for use as gears and bearings, templets, steel rule die-, blanking and form-blocks, electrical switchgear and leaf springs or as finished parts made to specifications. Delivery, about 8 wk. **Lignostone Import Co, PO Box 65, Gracie Sta, New York 28.**

Circle 301 on Reader Service Card

100% solids epoxy coating

is single component coating for continuous operation to 311 F. High-temperature, rigid epoxy system is curable at elevated temperature for short period of time. Heavy coatings are obtainable. Viscosity can be adjusted to yield build of 10 mil and thicker. Coating can be applied by dip or brush methods. **Columbia Technical Corp, 24-30 Brooklyn-Queens Expressway West, Woodside 77, NY.**

Circle 302 on Reader Service Card

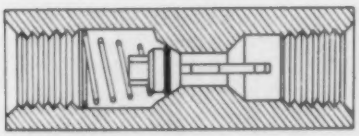
Potentiometer-operated temperature controller . . .

is based on a transistor-equipped amplifier-relay circuit. Temperatures are sensed by heat-sensitive thermocouple that is inserted into medium to be controlled. Accurate temperature control is said to be possible with resistances of as much as 20 ohm in lead wire between controller and thermocouple. Temperature adjustments are made by turning dial on cover of panel. Transparent window provides settings and three lights on panel indicate if power is on and whether temperatures are above or below set point. Nonindicating controller includes built-in proportioning unit that prevents temperature overshoot. Temperatures from −200 to 2000 F can be controlled to within 4 deg F. Also available is controller with equivalent ranges on Centigrade scale. Controller is $150 list, plus cost of thermocouples. **Minneapolis-Honeywell Regulator Co, Control Devices Div, 2753 Fourth Ave S, Minneapolis 9.**

Circle 303 on Reader Service Card

Potting leakage is prevented in potted equipment, such as plug-in subassemblies, by prepotting the terminal side of connectors with foamed elastomer before unit is assembled. Elastomer prepotting, which prevents leakage of epoxy resin and also provides nonrigid installation for connector terminals to prevent shorts or arc-over, is utilized extensively throughout equipment produced by this firm. **Librascope Div, General Precision Inc, 808 Western Ave, Glendale 1, Calif.**

Circle 304 on Reader Service Card



One-piece check valves . . . allow free fluid flow in one direction and block reverse flow. Leakproof bodies, in brass, steel or stainless steel, have soft seats. Horizontal poppet guide provides seating, checking and in-line self-cleaning action. Positive poppet stop prevents overcompression of stainless steel spring. Built for operating pressures to 5000 psi. Available with ⅛ through 1 in. dry seal threads or AND-10050 ports with straight threads. Prices range from $2.85 for ¼-in. unit to $25.20 for 1-in. unit, list. From stock. **Manatrol Corp, 2372 W 7th St, Cleveland 13.**

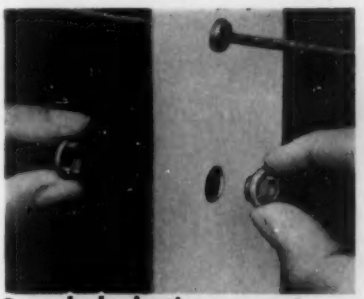
Circle 305 on Reader Service Card

Nylon captive sealing washer for screwed assemblies is suitable for applications of up to 200 psi working pressures. Washer is pushed over screw threads and flexible tongues on ID of seal spring into undercut or screw thread to retain washer when plug, bolt or adaptor to which it is fitted is removed. For use to 212 F. Available for bolts up to 1⅛ in. In quantities of 50,000 and over, priced at $3.60 per 1000 for ¼-in. sealing washers; $4.74 per 1000 for ½-in. units; $14.28 per 1000 for 1-in. units, all FOB NYC. **V P Black and Associates, 4832 Philadelphia Dr, Dayton 5, Ohio.**

Circle 306 on Reader Service Card

Dc plug-in power supplies . . . are highly regulated, transistor-equipped units with extremely low temperature coefficient, 0.003%/deg C. Available in voltages to 36 v and currents to 500 milliamp. Miniature units are said not to be damaged by continuous shorts or momentary overloads. For inputs of 105-125 v ac; outputs, fixed and variable, of up to 36 v dc and 500 milliamp. Reported to have less than 15 milliv total drift for 8 hr. Withstand ambient temperatures of 14 to 140 F. Size is 3.5 x 3.75 x 6.5 in. Weighs 3 lb 6 oz. Price for fixed-output units, $155; for variable-output units, $185. Delivery, 2 to 4 wk. **Valor Instruments Inc, 13214 Crenshaw Blvd, Gardena, Calif.**

Circle 307 on Reader Service Card



Snap-lock plastic grommet . . . insulates and supports wire, cable or tubing from mounting panel, chassis, wall, housing or similar surface. Grommet halves are inserted in panel hole and snapped together, locking in place. Available in No. 3 size with ⅜ in. hole dia; No. 4 for ½ in. hole dia and No. 6 for ⅝ in. hole dia. Can be color-coded. **Budwig Mfg Co, PO Box 4212, Glendale 2, Calif.**

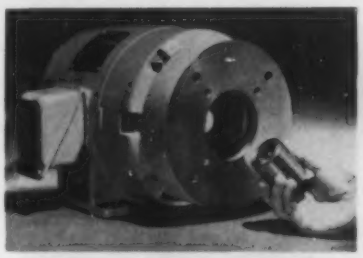
Circle 308 on Reader Service Card

Standard flexible-shaft assemblies . . . assembled from stock components are offered in over 180 variations. Available in four cable sizes, 0.130, 0.150, 0.187 and 0.250 in., as standard flexible shaft for industrial use and as standard panel-mounted flexible shaft with mounting nuts as part of shaft itself. Also offered with monodirectional cable for motor-driven or high-speed applications and bidirectional cable for hand-operated control applications. **F W Stewart Corp, 4311-13 N Ravenswood Ave, Chicago 13.**

Circle 309 on Reader Service Card

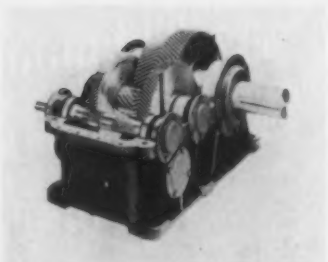
Direct-acting solenoid valves are bronze, two-way packed-type, spring-loaded for positive closing. General-service valves are available in eight sizes from ⅜ to 2½ in. for max pressures from 40 psi for ⅜ and ½ in. sizes to 4 psi for 2 in. valves. Prices start at $35 for ⅜ and ½ in. sizes. Suitable for applications requiring large-port, low-pressure, direct-acting solenoid valves. **J D Gould Co, 4707 Massachusetts Ave, Indianapolis 18.**

Circle 310 on Reader Service Card



Spline-coupled pumpmotors are said to be almost 3 in. shorter than present open-adapter design. Pump motor is furnished with coupling, which is splined on motor end and has conventional bore and keyway on pump end. Motor, with pump-mounting face on one end, is available in all ratings now supplied in NEMA frame size 182, 184, 213 and 215, nominally 1 through 5 hp, except for explosion-proof construction. In addition, dripproof and nonventilated motors can be supplied with pump-mounting faces on both ends of motor. **General Electric Co, Schenectady 5.**

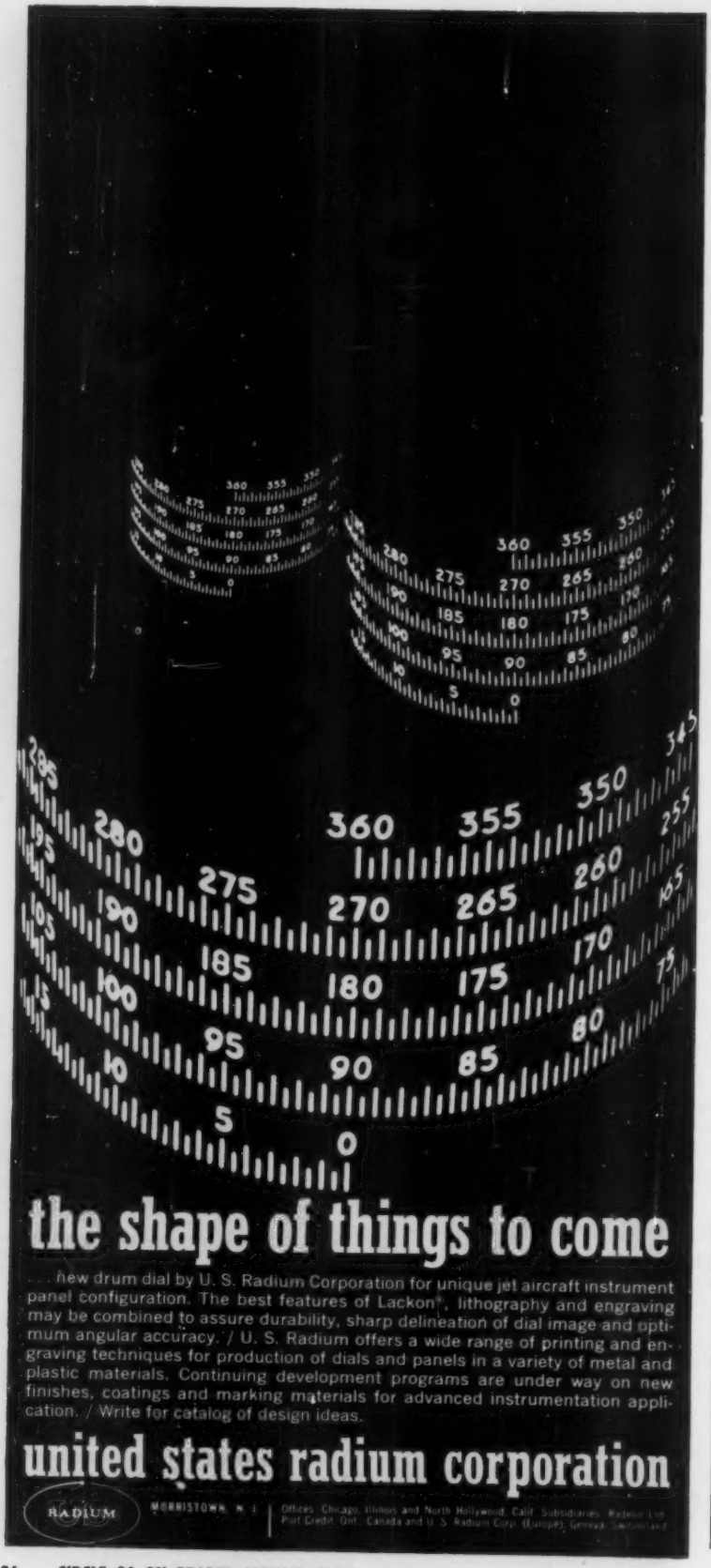
Circle 311 on Reader Service Card

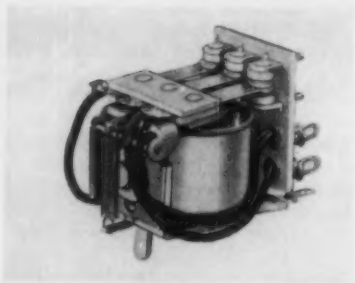


Parallel shaft speed reducers are now available in 57 sizes. Line includes single reduction units in 17 sizes with ratios up to 9.78:1 and capacities to more than 2800 hp; double reduction units in 20 sizes with ratios from 11.4:1 to 70.6:1 and capacities to more than 1700 hp; triple reduction units in 20 sizes with ratios from 31.4:1 to 29.2:1 and capacities to more than 900 hp. Shafts can be arranged to suit specific drive requirements. **Link-Belt Co, Dept PR, Prudential Plaza, Chicago 1.**

Circle 312 on Reader Service Card

continued on page 86


the shape of things to come
. . . new drum dial by U. S. Radium Corporation for unique jet aircraft instrument panel configuration. The best features of Lackon®, lithography and engraving may be combined to assure durability, sharp delineation of dial image and optimum angular accuracy. / U. S. Radium offers a wide range of printing and engraving techniques for production of dials and panels in a variety of metal and plastic materials. Continuing development programs are under way on new finishes, coatings and marking materials for advanced instrumentation application. / Write for catalog of design ideas.
united states radium corporation
RADIUM
MORRISTOWN, N. J.
Offices: Chicago, Illinois and North Hollywood, Calif. Subsidiaries: Radelco Ltd., Port Credit, Ont., Canada and U. S. Radium Corp. (Europe), Geneva, Switzerland



General-purpose ac-dc relay

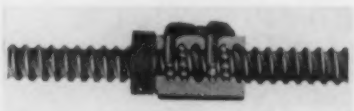
is said to be low-cost unit that is available open, with transparent plastic cover and hermetically sealed; with SPDT, DPST and 3PDT contacts. Offered for 5- and 10-amp ratings, for dc operation to 220 v; ac operation to 440 v. Over-all dimensions are $1\frac{5}{16}$ x $1\frac{1}{4}$ x $1\frac{13}{16}$ in. Features modular construction, armature hinge-pin (centerless ground of stainless steel) with oversize precision-reamed bearing surfaces, glass insulation, independently riveted coil terminals, molded nylon bobbins and built-in contact wipe. **Magnecraft Electric Co, 3350Y W Grand Ave, Chicago 51.**

Circle 313 on Reader Service Card

High-strength steels . . .

are available in 1) a series of constructional alloys that permit building of heavy-duty industrial equipment with increased strength while effecting savings in time and fabrication expense; 2) companion series reported to offer high abrasion-resistance at high yield strengths. Both series derive their properties primarily from special procedures in heat treating, quenching and tempering. Constructional steel series is available in three grades, representing min yield strengths of 90,000 psi; 100,000 psi and 110,000 psi. Abrasion-resistant series is available in two sets of hardness values, with Brinell hardness rating of 340 to 380 and with min hardness rating of 400 Brinell. Typical yield strength is about 140,000 psi. **Jones & Laughlin Steel Corp, 3 Gateway Center, Pittsburgh 30.**

Circle 314 on Reader Service Card



Standard ball screws, splines

in range of sizes are reported to offer 90% efficiency. Extreme positioning accuracy accomplished with ground thread specials is sacrificed in these standard assemblies and solid preloading is impractical due to lower tolerances. Applications lie principally in moving of loads with low break-

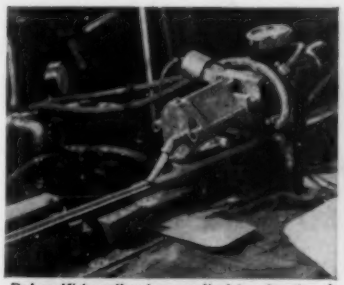
continued on page 88

How FRUEHAUF rolls 'em out stronger, lighter

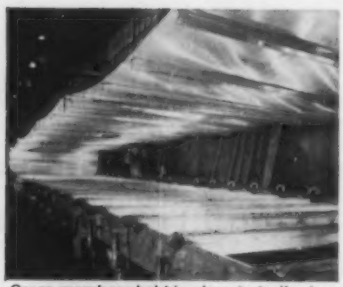
...with adhesives based on THIOKOL polysulfide polymer

Fruehauf Trailer Company adapts the unique bonding action of polysulfide liquid polymers in a unique way. Polysulfide-base compound is used to join 1-piece roof top to roof bows. Result: roof span is lighter, stronger, and completely weathertight. Rubbery cushion between roof and structural members helps absorb shock of road travel. The use of polysulfide, for the first time, permits bonding of bows and roof sheet for greatly increased structural strength. This is another outstanding example of the industrial applicability of adhesive and sealing compounds properly formulated with THIOKOL polysulfide polymers—and of the benefits that accrue.

For further information about how THIOKOL polysulfide polymers serve industry, and how they may help you—write to THIOKOL on your letterhead.



Polysulfide adhesive applied to structural cross-members by machine.



Cross-members held in place to trailer top sheet by cured sealing compound.

Providing extra seal at roof corners by brushing on polysulfide-base compound.

Skylights also sealed with polysulfide-type sealants as added precaution to guarantee complete weather-tightness.

Thiokol®
CHEMICAL CORPORATION
780 N. Clinton Avenue, Trenton 7, New Jersey
In Canada: Naugatuck Chemicals Division, Dominion Rubber Co., Elmira, Ontario

Not all polymers are polysulfide. When purchasing adhesives or sealants, be sure to specify THIOKOL polysulfide-base sealants. THIOKOL makes only the polysulfide polymer, not the finished product.

®Registered trademark of the Thiokol Chemical Corporation for its liquid polymers, rocket propellants, plasticizers, and other chemical products.

all the advantages of Teflon* plus unique resistance to cold flow

If you can't keep bearings lubricated—if they operate in corrosive atmospheres, or in high or low ambient temperatures – RILOAD® bearings will work where nothing else will. Teflon's inherent low coefficient of friction remains the same from – 450° to 500° F., and it resists virtually any corrosive atmosphere.

RILOAD bearings are custom made with glass filled Teflon (increasing wear life 500 times) molded onto perforated metal. This unique design increases mechanical strength and gives high resistance to cold flow; PV values in the order of 20,000 have been applied. Riload Bearings are designed to dissipate heat efficiently and will operate in hot applications where other bearings fail.

RILOAD bearings are designed for press fit into the bearing housing with a custom fit to the shaft O.D. For full technical information on your particular application send design data to: Modern Industrial Plastics Division, P. O. Box 1019, Dayton, Ohio.

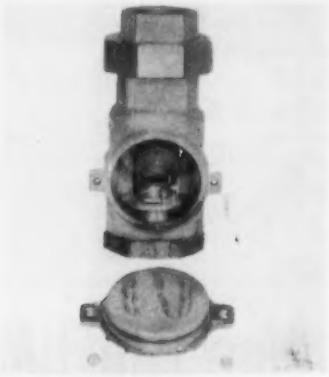
*Registered trademark of Dupont

Modern Industrial Plastics Div.
Dayton, Ohio

DURCO

away friction, min space requirements and low service requirements. Lower-cost standardized ball-screw and ball-spline assemblies can now be specified where extreme precision is not required. **Beaver Precision Products Inc, Clawson, Mich.**

Circle 315 on Reader Service Card



Vertical check valve . . .

holds prime in liquid lines. In operation, disk swings completely out of flow passage, for min pressure drop. When flow stops, disk swings downward to raised seat. Compensator ring provides even pressure on all sides of disk against seat, eliminating uneven seating or loss of prime. Pressure limit is 125 psi; temperature limit is 225 F. Available in 1½ in. size. With composition disk, prices range from $14.50 to $16.45; with bronze disk, from $12.75 to $14.70. **OPW-Jordan Corp, 6013 Wiehe Rd, Cincinnati 13.**

Circle 316 on Reader Service Card

Size 8 hysteresis motor . . .

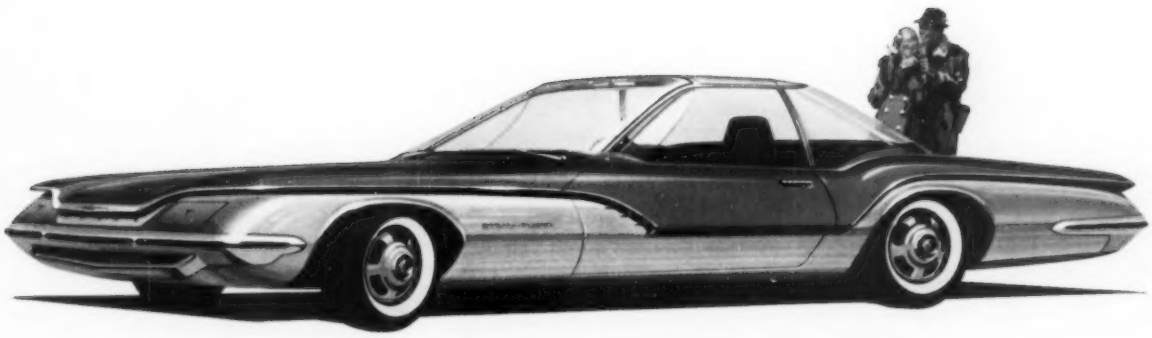
measures 0.960 in. long and provides hunt-free synchronous rotation. Synchronous speed is 8000 rpm at 55 v. Said to meet environmental requirements of MIL-E-5272. Single- and two-phase units are offered. Torque (pull-in) is 0.025 in.-oz. Weighs 1.25 oz. Total power is 5.1 w. Suitable as constant-speed drive for computers and navigational devices. **Kollsman Motor Corp, Dublin, Penna.**

Circle 317 on Reader Service Card

Miniature temperature sensor . . .

is said to have repeatability accuracy of better than 100 parts per million in precise temperature measurements, monitoring or control applications. Measuring 0.138 in. dia and 0.4 in. long, resistance thermometer has accuracy of better than 0.05 ohm or 0.05 F. Sensing element of chemically pure platinum is fully annealed and is sus-

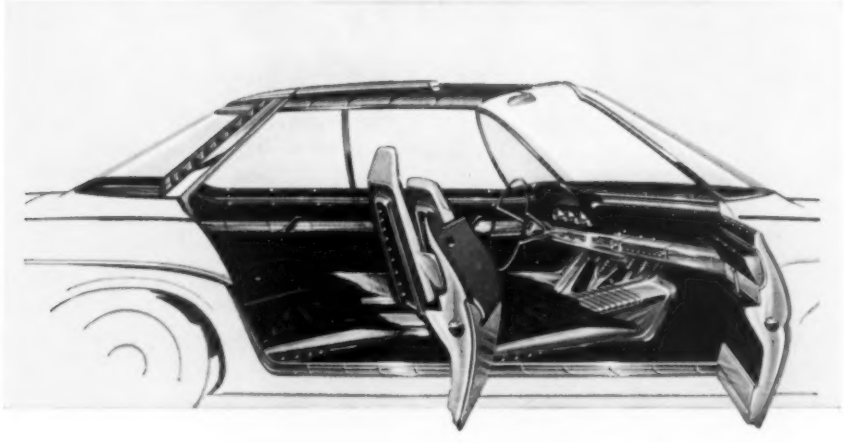
continued on page 91



stainless steel

No other metal has the strength, beauty and versatile qualities that serve you so well today and promise so much for tomorrow.

There is nothing like stainless steel for AUTOMOBILES



McLouth Steel Corporation,
Detroit 17, Michigan

Manufacturers of high quality Stainless and Carbon Steels

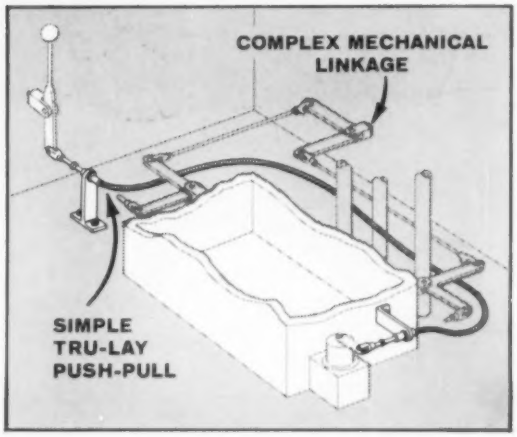
Look for the **STEELMARK** on the products you buy.

McLOUTH STAINLESS STEEL

ACCURATE REMOTE CONTROL FOR HUNDREDS OF PRODUCTS

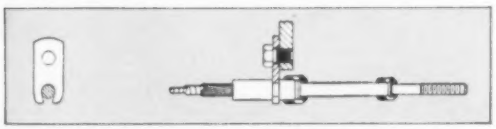
— — with Tru-Lay *PUSH*-PULL Controls

If your products involve remote control—electrical, hydraulic, pneumatic or direct—TRU-LAY PUSH-PULL FLEXIBLE CONTROLS can help solve your design problems. They provide positive remote control over short or long distances—up to 150 feet from the control point. Because they operate while flexing, they can snake around obstructions. They will not buckle. They are ruggedly constructed, easily installed and operated, sealed against dirt and moisture, and will handle jobs with as much as 1,000 lbs. input. PUSH-PULL CONTROLS are simple, have but one moving part, are noiseless and give a lifetime of accuracy. Mechanical linkages, on the other hand, are complex. Unlike PUSH-PULL CONTROLS, they are made of many parts, wear at many points, and produce increased backlash, vibration rattles and lost accuracy.

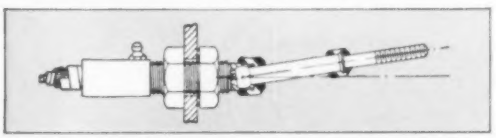


THESE FEATURES HELP SOLVE DESIGN PROBLEMS

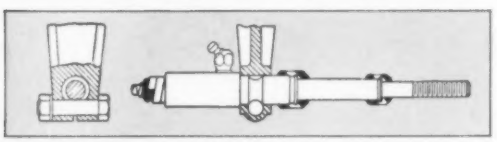
Anchorages



Clip anchorage • a simple clip for light loads

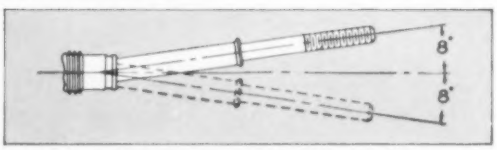


Bulkhead anchorage • for heavy-duty installations



Machined bracket anchorage • can be furnished for mounting any PUSH-PULL cable at the swivel terminal

Swivel Action



Standard assemblies have end fittings with a swivel movement of ± 8° to compensate for misalignment and rise or fall of lever arms. Swivel joints, and the sliding ends, are sealed against dirt and moisture.

PUSH-PULL DATA FILE SHOWS HOW TO SIMPLIFY, IMPROVE DESIGN

• Write for your PUSH-PULL Data File. It contains a complete set of engineering bulletins which describe in detail the operation of PUSH-PULL CONTROLS, their applications, features and advantages.

ACCO

PUSH-PULL CONTROLS

Automotive and Aircraft Division • American Chain & Cable Company, Inc.

601-E Stephenson Bldg., Detroit 2

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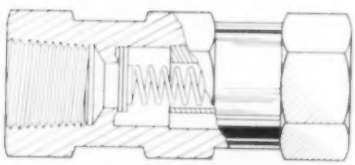
pended inside hermetically sealed metal case. Unit is vibration- and shock-damped. Operating range is —100 to 400 F with change of resistance of about 1 ohm per F. Linearity is reported to be less than 1% of full range. Sensor can be immersed in most electrically nonconductive liquids and has time constant of 2 sec in moving liquid or comparable heat sink. From stock in limited quantities. Price ranges from $124 each for 1 or 2 units to $89 each for 51 to 100. **Minco Products Inc, 740 Washington Ave N, Minneapolis 1.**

Circle 318 on Reader Service Card

High-pressure shut-off valve . . .

with full-flow passage and O-ring sealing has right-angle configuration for mounting convenience. Available with single inlet and outlet; single inlet and two outlets; two inlets and single outlet. Stainless steel valve can be coupled with choice of O-ring for use with any gaseous or liquid service medium. Operating temperature range is —40 to 450 F; operating pressure range, from 0 to 6000 psi with zero leakage. Proof pressure is 7500; burst pressure, well over 20,000 psi. Valve stem and seat permit gradual throttling of flow as valve is actuated. 20 in.-lb of force actuates valve under full 6000 psi pressure. **Circle Seal Products Co Inc, 2181 E Foothill Blvd, Pasadena, Calif.**

Circle 319 on Reader Service Card



Disk-type check valve . . .

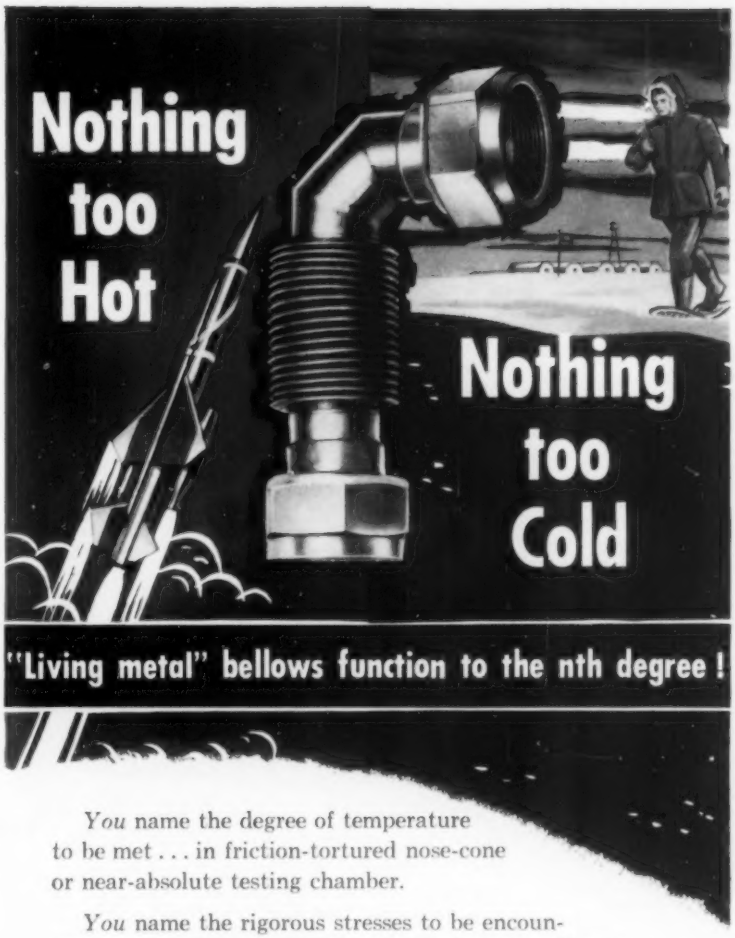
with one-piece body has calculated burst pressure of 20,000 psi. Only moving part is small disk. Opening pressure is 2 to 8 psi and the soft-surface disk provides dead-tight sealing at all pressures in air, oil and water. Presently available in brass in ¼, ⅜ and ½ in. female pipe. ¼-in. size is $3.75. **Bodnar & McDermott Mfg Co, 19 Beechwood Ave, Mt Vernon, NY.**

Circle 320 on Reader Service Card

220-mc counter-timer . . .

combines all-solid-state 10-mc counter-timer and plug-in vacuum tube hetrodyne converter in one package. Two converter plug-ins are available: one to cover frequency range from 10 to 100 mc and the other to cover 100 to 220-mc range. Complete instrument weighs 53 lb, re-

continued on page 94



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You name the rigorous stresses to be encountered . . . the severe pressures or corrosive atmospheres.

You name the problem . . . and our engineers will deliver a "living metal" bellows assembly that answers it!

Custom-designed and manufactured by the company that invented the seamless metal bellows, Robertshaw Sylphon® Bellows are available in a wide variety of metals, according to the properties desired . . . brass, phosphor bronze, beryllium copper, monel, A-286 stainless steel, inconel, inconel-X and now in Ni-Span-C.

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CIRCLE 91 ON READER SERVICE CARD

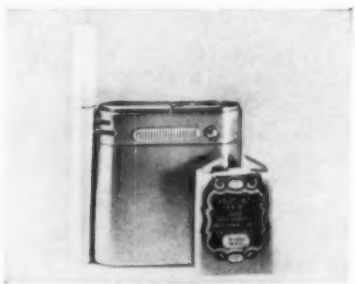
the LEAD newsletter

Vol. 2 No. 4

Unique Power Requirements Provided By Lead

Five Kilowatt Thermoelectric Generator

Ideal thermoelectric materials are hard to find. They must be semiconductors, substances with electrical properties midway between insulators and conductors, which are used in transistors and other solid state devices. However, used in a thermo-electric device, good electrical conductors generate very little voltage, good electrical insulators very little current. This restricts the search to a narrow range of materials that conduct electricity much less than metals do, but better than ordinary semiconductors. Westinghouse engineers, says Fortune magazine, have come up with five-kilowatt generator incorporating a variety of thermoelectric materials, each of which works best at a different temperature. At the hot (650° C.) end of one leg of the element is a wafer of germanium telluride, zinc antimonide, and finally, at the cold end (100° C.), an alloy of bismuth and antimony tellurides. The other leg consists of wafers of lead telluride and an alloy of bismuth and selenium tellurides. Potentially this carefully selected sequence of materials has a thermal efficiency of better than 15 per cent.



Two-Volt System Powers Cigarette Lighter-Flashlight Combination

A New York company markets a cigarette lighter with a two-volt lead-acid cell ignition system. When a "light" is desired, a mere touch slides out a coiled resistance wire that glows incandescently and lights the wick. Several amperes of current flow during the few seconds the resistance wire is aglow. Even chain smokers can expect three to six months of service before replacement of the tiny lead-acid cell is necessary. The cell, weighing less than an ounce, is plastic covered and completely sealed, measuring 1-1/2 x 1-1/6 x 3/8 inches. In addition to being a cigarette lighter, the same lead-acid battery powers a totally functional flashlight which is built into the unit. The battery's size and characteristics indicate interesting electronic applications where compactness and intermittent high drain capabilities are requirements.

Battery Powered Trucks and Cars

Whether power requirements are minor, such as required in the lighter or major, such as needed to carry heavy loads economically over long distances, there is a lead-acid storage battery to meet every need. Because operating costs are attractively low, lead battery powered electric vehicles are a practical reality despite present slightly higher initial costs. Economy-minded local fleet pick-up and delivery truck operators see great possibilities for electric street trucks that are being marketed by the Cleveland Vehicle Co., to handle a 50-mile route with 200 pay stops. The reason: cost, a mere one-and-a-half cents a mile on the average stop-start 20 mile route. These highly efficient lead-acid storage batteries, with a low weight to power ratio can be fully recharged overnight by "plugging" into any 110 or 220-volt outlet. Passenger cars with the same economy features as exhibited by the trucks, produced by the Henney Motor Company of Canastota, New York, use an imported unitized Renault Dauphine body which is powered by 640 pounds of heavy-duty lead-acid batteries generating 72 volts of motive power, and 12 volts for lighting and control. Capable of top speeds up to 40 mph this "hot" car travels more than 50 miles before needing a recharge. It operates extremely quietly, and enables the motor to live practically forever.

Lead Zirconate-Titanate Shakes Out The Dirt

Lead zirconate-titanate, a new high efficiency, high Curie temperature piezoelectric ceramic, is the transducer material used in an ultrasonic cleaning system introduced this year by Branson Ultrasonics of Stamford, Connecticut. The system has cleaning power equivalent to the old barium titanate systems but at only two-thirds the initial cost. Although piezoelectric lead zirconate-titanate is somewhat costlier than barium titanate, its higher electromechanical efficiency generously compensates by requiring less expensive driving gears, while its higher Curie temperatures provides full-wave operation without danger of depolarizing. Total efficiency of the new lead-zirconate-titanate system is 90 per cent compared to 70 per cent for barium titanate systems. Furthermore a new transducer design concept has cut replacement costs of the transducers to negligible levels. The sandwich designed transducer consists of a thin section of ceramic clamped between two pieces of metal and operates at 25 KC. It offers advantages of: higher operating temperature (200° F.); and flat tuning characteristics which reduce the need for close frequency control of the generator. In brief: lower initial cost and lower maintenance costs resulting from the use of lead zirconate-titanate transducers make this new ultrasonic cleaning system competitive in uses formerly closed to ultrasonic cleaning.

For information or technical assistance on new lead developments and applications—and how they can relate to your products—write to: Lead Industries Association, 292 Madison Avenue, New York 17, N. Y.

LOOK AHEAD WITH LEAD

interchangeable with all standard JIC cylinders

With the introduction of the ALL NEW T-J Squair Head, Tomkins-Johnson now offers industry the most complete design range of air and hydraulic cylinders. Presently available in bore diameters from 1½ to 8 inches, the T-J Squair Head is an interchangeable cylinder which produces maximum force and efficiency, with minimum pressures... and is also adaptable to the use of low pressure oil as the working medium. Write to The Tomkins-Johnson Co., Jackson, Michigan, for Bulletin #SQ 10-58 and complete details.

CHECK THESE 10 POINTS OF T-J SUPERIORITY

1 One Piece Piston

2 Hard Chrome Cylinder Bore and Piston Rods

3 High Tensile Steel Tie-Rods

4 Cushion Adjusting Screw, Externally Adjustable

5 New Super-Cushion for air, or Self-Aligning Master Seal for Oil (T-J Patents)

6 Solid Steel Heads and Mounting Plates Standard all Models

7 Port Design Allows Minimum Pressure Drop on Inlet or Outlet

8 "V" Type, Self-Adjusting Rod Packing

9 Piloted Packing Gland–Absolute Alignment

10 Piston Rod, Extra Strong–Polished and Chrome Plated for Efficiency and Protection

T-J TOMKINS-JOHNSON

Are Small Precision Metal Parts Getting In Your Hair?

If you need precision in small metal parts you can get it from Torrington—plus exactly the right finish, temper and hardness required for your needs. Moreover, Torrington can produce such parts at high speed and a remarkably economical cost. We are the leading specialist in this field—with the specialized skills, engineering experience and facilities to save you money. If you have small parts to be manufactured in large quantities why not let Torrington solve your entire problem. Let us hear from you and your request will receive prompt action.

progress through precision **SPECIAL METAL PARTS**

THE TORRINGTON COMPANY Torrington, Conn.

quires 125 w power and measures 14 x 17 x 13 in. deep. Solid-state counter section combines functions of counter, time interval meter and frequency/period meter. It performs seven basic functions selectable by front panel switch. Output from each decade-counting unit will operate digital printers, punches, in-line readouts and other data-processing equipment. Measurement ranges are 220 mc for frequency; 0.1 microsec to 10^5 sec for time interval; 0.1 microsec for period. Accuracy is said to be ±1 count ± oscillator stability; sensitivity to be 0.25 v rms. **Computer Measurements Co, 12970 Bradley Ave, Sylmar, Calif.**

Circle 321 on Reader Service Card

Pressure-gage snubber . . . has 13 different settings. Max working pressure is 5000 psi. Variations in snubbing action are accomplished by selection of one of various combinations of three stainless steel pins, each having a different diameter. Snubbing chamber is located on side, permitting changing of pins without disrupting line connections. Made in high-strength forgings of brass and stainless steel in sizes ¼ and ½ in. internal pipe threads. **Republic Mfg Co, 15655 Brookpark Rd, Cleveland 35.**

Circle 322 on Reader Service Card

Timer motor and gear train . . . for clocks and timing applications has noise level said to be so low that at 3-in. distance, level cannot be measured over soundroom threshold noise. This single unit is permanently lubricated and sealed against dust and humidity. Current requirement is 1 w. Heat rise is 25 to 30 F. Size is 2½ in. OD and 1¹³⁄₁₆ in. deep. Two 6-in. stripped and tinned leads are furnished as standard. **Borg Clock Div, Amphenol-Borg Electronics Corp, Delavan, Wis.**

Circle 323 on Reader Service Card

Molded and extruded Teflon-FEP shapes are now being fabricated. Intricate shapes with wall sections of min thickness of 0.020 to 0.030 in. are possible. Resin

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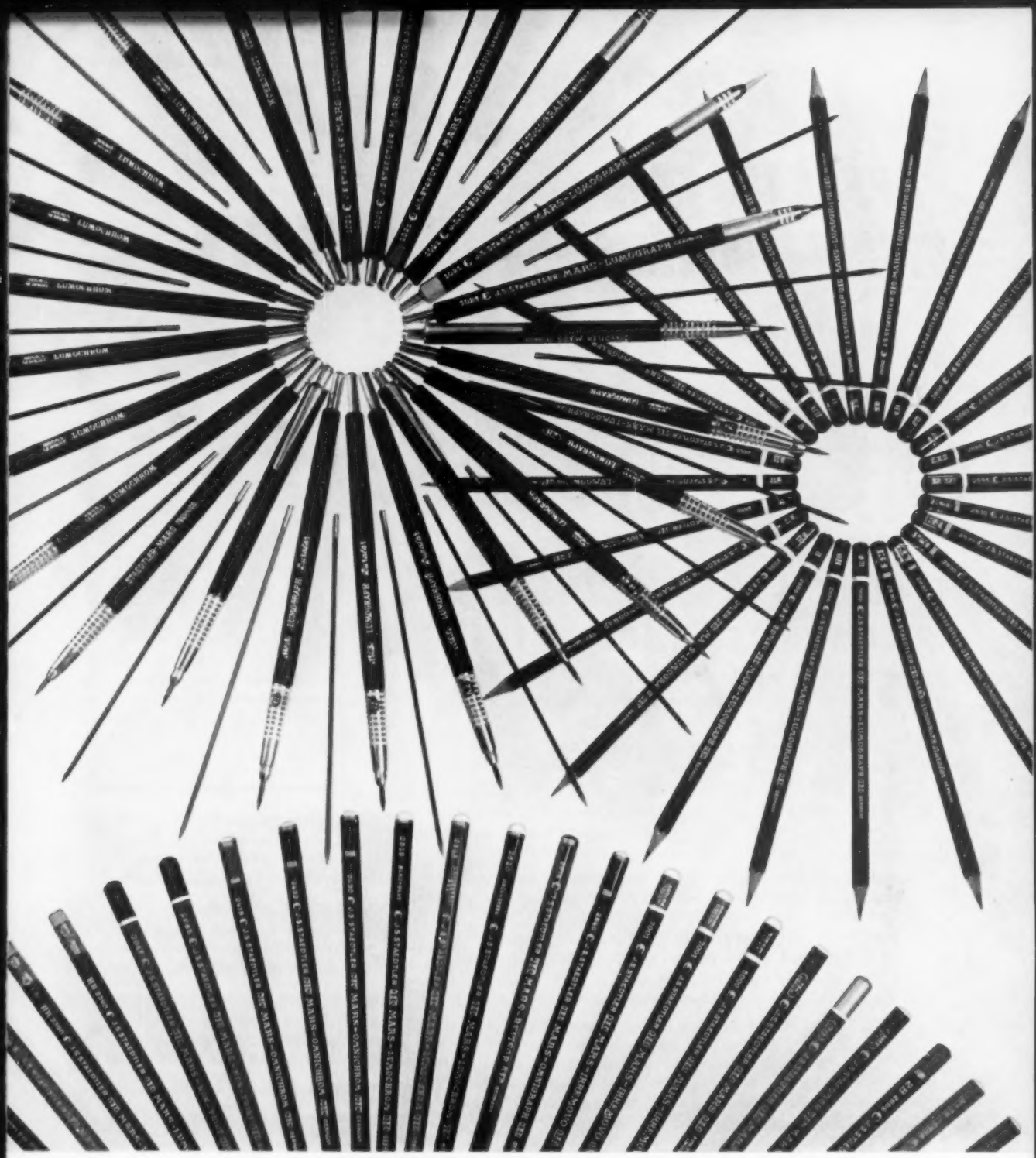

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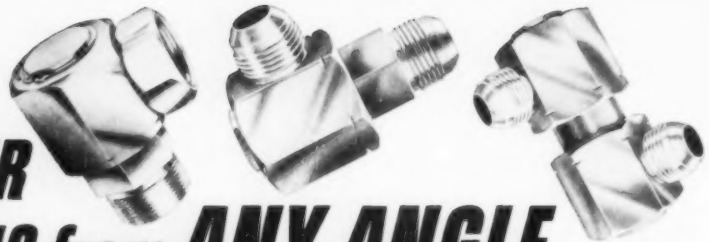

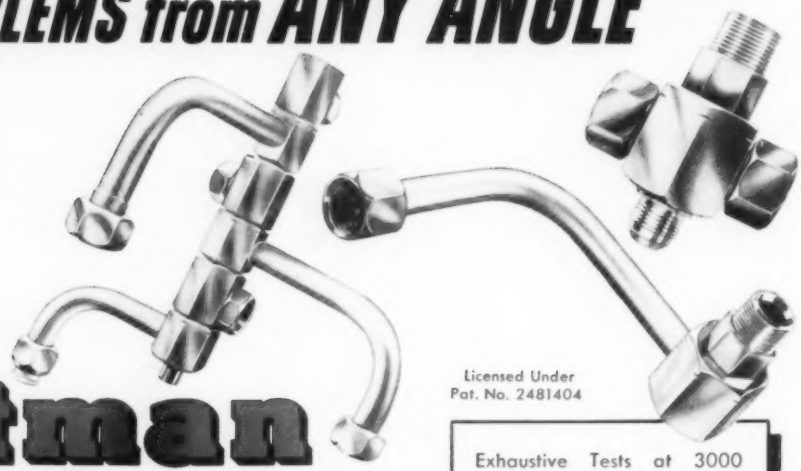

with Eastman Low Cost Industrial SWIVEL CONNECTORS

Licensed Under Pat. No. 2481404

Yes, you can approach your design problems from *any angle* — from any of the six sides of EASTMAN'S *newly improved* Industrial Swivel Connector.

Never before has any fitting equaled its adaptability and versatility. You can stack them, line them up parallel, horizontal or vertical . . . in a "T," if need be.

Not only can you simplify design problems, but you can improve the maneuverability of your equipment . . . raise or lower buckets or blades. You are able to change the angle of the cut right or left, up or down . . . *on the go.*

EASTMAN Industrial Swivel Connectors eliminate costly hose failures due to excessive flexing; permit use of shorter lengths of hose and help eliminate complicated assemblies.

Improved interior design provides "balanced" fluid flow *at any angle.* Chrome hardened, cadmium plated interior surfaces, burnished to a mirror finish, improve performance. SIX sealing rings: 2 leather dust seals, 2 synthetic back-up washers and 2 quad rings of oil-resistant rubber (−40° to +200°) assure dust-free field service and less down time.

If you have been "designing around" Swivel Connectors because of high cost . . . rest assured that EASTMAN'S Industrial Swivel Connectors will not only reduce your original cost but lower your customers' operating costs as well.

Exhaustive Tests at 3000 p.s.i. through 1½ million cycles, with the connector covered with abrasives and dirt, simulating field conditions, proved EASTMAN'S Industrial Swivel Connector satisfactory in every respect and did not cause failure of any kind.

Cut corners while you cut costs with these economical Eastman Industrial Swivel Connectors.

Eliminate installations of lengthy, complicated hose assemblies, junction boxes and multiple adapters.

Improve uniform power delivery and operating efficiency, reduce costly field replacement and down time.

- **LOW TORQUE**—Freedom from friction, even under high pressure.
- **WIDE RANGE**—Operating pressures up to 3000 p.s.i. trouble-free operation through wide temperature range (−40° to +200°).
- **ROTATION**—Full 360° for all manifolds.
- **SIZES**—Steel, plated for corrosion protection—½", ¾", 1", 1¼". Other sizes available on request.

Write for Technical Bulletin No. 59 on Eastman's new improved swivel connector.

Eastman MANUFACTURING COMPANY
DEPT. PE-10 MANITOWOC, WIS

can be melt-processed in conventional extrusion and molding equipment. Continuous-service temperature range is —395 to 400 F. Stock shapes are available. Garlock Inc, 448 Main St, Palmyra, NY.

Circle 324 on Reader Service Card

Bonded dry-film lubricant . . .

combines equal volume of resin and hardener. Coating is said to match properties of currently available resin-bonded, heat-cured coatings complying with military and manufacturers specifications. Operates continuously from —100 to 725 F with coefficient of friction of 0.035. Requires no baking oven or drying equipment and is ready for use 8 to 24 hr after application. **Drilube Co, 723 W Broadway, Glendale 4, Calif.**

Circle 325 on Reader Service Card

Flow-control valve . . .

operates on constriction or throttling principle. Available in various sizes and materials for any liquid, gas, solid or slurry at up to 125 psi at 230 F, it is controlled by air or hydraulic pressure that can be regulated manually or automatically. Of resilient construction, positive-acting and explosion-proof valve installs in any position in piping system and needs no large external mechanical members. Valve is also self-cleaning. Said to respond instantly and accurately to temperature or pressure signal impulse. **D M Connor and Co, PO Box 162, S Plainfield, NJ.**

Circle 326 on Reader Service Card

115-v series-wound motors

for 60-cps operation, carry continuous-duty ratings up to ½ hp at 5000 rpm and up to 1 hp at 10,000 rpm. Utilize ballbearing construction. Motors are designed for end mounting with cast-iron housings and open, end-to-end ventilation. Housing length is 7⅛ in.; mounting face dia is 5½ in. Weighs 12.5 lb. **Universal Motor Div, Robbins & Myers Inc, Springfield, Ohio.**

Circle 327 on Reader Service Card

Ac, dc tach generators . . .

are reported to be low-cost units to provide speed indication for machine tool or industrial process applications involving speeds up to 5000 rpm. Base mounts are adaptable to variety of mounting arrangements. Shaft diameter has been increased to $\frac{3}{16}$ in., making shaft strength about three times that of former models. Redesign of ac tach generator has increased number of poles from two to six, resulting in min full-scale speeds of 0-300 rpm with suitable accuracy. Both ac and dc units have rated outputs of 20 v per

continued on page 99

NEW MASSIVE MC NYLON PLATE NOW AVAILABLE!

• Huge MC Nylon plate—the largest ever produced—is now available for wear plates, panels, tooling, fixtures and other applications which need nylon's unique mechanical or structural properties.

Polymer's exclusive revolutionary new processing techniques make production of large plate practical with price reductions of 15% under nylon plate presently available. Standard stock availabilities now include thicknesses from ½" up to 4" and in 2' by 4' sections. Availabilities to date were limited to 1½" maximum thickness in 10" widths. MC Nylon now opens new design possibilities and manufacturing economies. On special order plates of over 6" thickness in sections of 4 foot widths and 10 foot lengths can be supplied.

In tubular bars, the specially formulated bearing material now costs less than continuous cast bronze bushings of similar size, with prices up to 50% below other nylons.

MC Nylon tubular bars are made in OD's from 2" to 15" with wall thicknesses of ⅜", ½", ¾" and 1". Rod up to 17" diameter is also available with special larger sizes and shapes made to order. Supplied in Polypenco blue.

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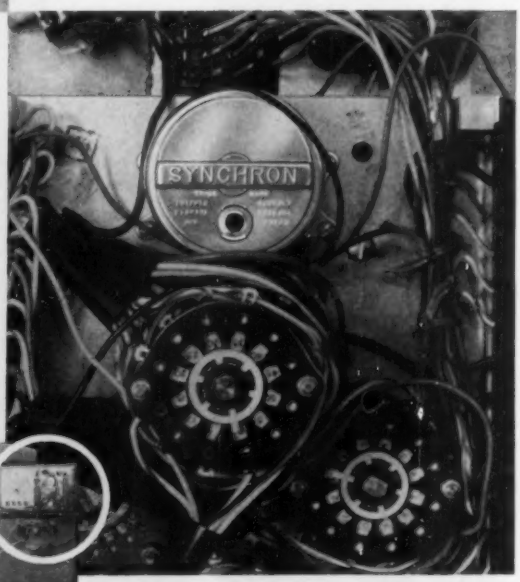
PRODUCT APPLICATION

HANSEN
SYNCHRON
TIMING MOTORS

Schulmerich
electro-mechanical
CARILLONIC BELL
systems . . .

Hansen SYNCHRON motors, the "heart" controlling the split-second timing of Schulmerich Carillonic Bells



SCHULMERICH CARILLONS, INC., world's largest manufacturer of electro-mechanical carillons, uses Hansen SYNCHRON Timing Motors to drive the program clock governing the all-automatic operation of these precision, perfect-tone instruments. Clock programming is offered at 15-minute intervals, 24 hours a day, 7 days a week. Scheduled to play at specified times, exactly to the minute — there is no allowance for plus or minus variation.

HANSEN SYNCHRON TIMING MOTORS were selected as an integral part of Schulmerich Carillonic Bells because they outperformed all other motors tested. Carefully controlled testing was based on four specifications: (1) instantaneous starting, (2) no time loss or gain, (3) absence of malfunction, and, (4) reliable, continuous operation for periods of a year or more. Depending on installation, motors operate at either 110 or 220 volts — 50 or 60 cycles.

SEND TODAY for informative folder containing specifications and technical data on all Hansen SYNCHRON motors and clock movements.

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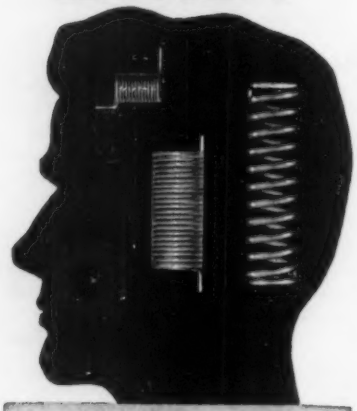
ELECTRIC MOTOR ENGINEERING, INC.
Los Angeles, Calif. — (OLive 1-3220)
Oakland, California
WINSLOW ELECTRIC CO.
New York, N.Y. — Essex, Conn. (SOuth 7-8229)
Philadelphia, Penn. — Cleveland, Ohio

Sweet's Product Design File

SPRINGS ON YOUR MIND?



• Your next thought should be of the Spring Engineers at John Chatillon & Sons. Send them your blueprints and specifications for study and recommendation.

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1000 rpm. Installation is said to be simplified by addition of terminal box that comprises entire opposite-pulley-end of generator. General Electric Co, Schenectady 5.

Circle 328 on Reader Service Card

Stock precision gears . . . in standard sizes from 48 to 120 DP, 10 to 40 teeth in stainless steel and 42 to 180 teeth in aluminum are certified to be AGMA Precision Class 1 or better. Gears, ranging from $\frac{1}{16}$ to $2\frac{1}{4}$ in. OD, are for use in instruments, meters, controls and in precision components. Boston Gear Works, Quincy 71, Mass.

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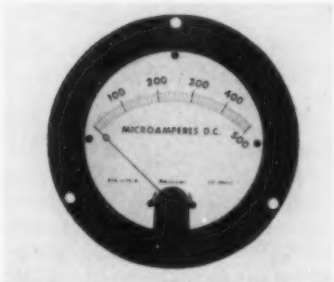

4½-in. panel meters . . . are all-metal, round and sealed units, with plug-in terminal construction. Available in 92 standard models in voltmeters, ammeters, milliammeters and microammeters. Said to meet specifications of MIL-M-10304A. Delivery, 30 days. Helipot Div of Beckman Instruments Inc, Fullerton, Calif.

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Teflon-coated wire cloth . . . for filtration applications is available in industrial grades. Coating can be applied evenly over entire surface of cloth and will not interfere with mesh openings in mesh sizes as fine as 180 per in. Teflon coating is said to hold water back and allow other liquids to pass through in filtration operations where water is present. Cambridge Wire Cloth Co, Cambridge, Md.

Circle 331 on Reader Service Card

Duplicate diazo master . . . enhances weak-line originals and permits direct negative-to-negative copying in normal room light. Also can be used for positive to positive copying. Develops in one step. Offers highest resolution on 0.005 in. clear acetate base that is sensitized for dry diazo processing. Emulsion is grainless and highly scratch resistant. Ozalid Div, General Aniline and Film Corp, 59 Corliss Lane, Johnson City, NY.

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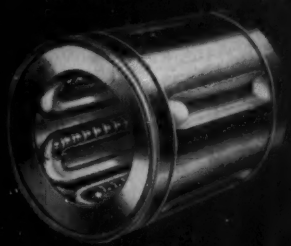
CIRCLE 99 ON READER SERVICE CARD

NOW! *Adjustable Diameter and Open* THOMSON

BALL BUSHINGS

Adjustable Diameter BALL BUSHING for Zero Clearance

The BALL Bearing for *all* your **LINEAR MOTIONS**



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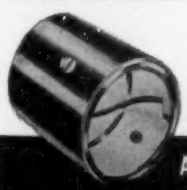
Open BALL BUSHING for Zero Clearance on Supported Shafts

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

Improve your product! Up-date your design and performance with Thomson BALL BUSHINGS!

LOW FRICTION • ZERO SHAKE OR PLAY
ELIMINATE BINDING AND CHATTER
SOLVE SLIDING LUBRICATION PROBLEMS
LONG LIFE • LASTING ALIGNMENT

The various types cover a shaft diameter range of ⅛" to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.



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Dept. H, MANHASSET, NEW YORK

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Seven large truck line terminals.
New York Central and
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2. Haleyville, Alabama

Convenient to Birmingham.
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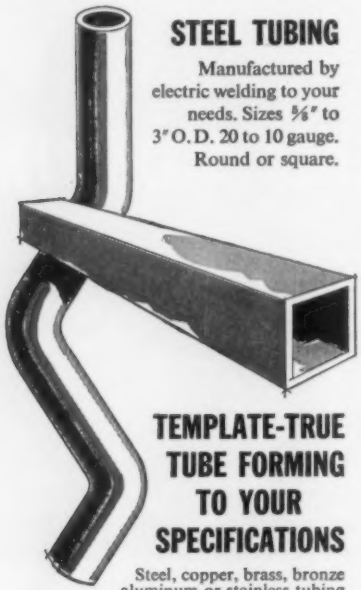

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TEMPLATE-TRUE TUBE FORMING TO YOUR SPECIFICATIONS

Steel, copper, brass, bronze aluminum or stainless tubing fabricated to your specifications. Sizes ⅜" to 6" OD, 20 to 10 gauge.

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DESIGN LITERATURE

Saturday Science

By the scientists of Westinghouse Research Labs. Edited by ANDREW BLUEMLE. E P Dutton & Co Inc, 300 Park Ave South, New York 10. 7 x 10 in., 333 pp. $5.95.

Back in 1957, Dr Milton Wachtel of the Westinghouse Research Labs had an idea. It was simply that talking about science education was useless; it was much more positive to provide scientific information to young people who wanted it. He bothered his colleagues until they agreed that he had something. So now, for a dozen or more successive Saturday mornings each year, about 200 seniors from 100 local high schools gather at the Labs for a series of lectures by members of the staff. The program is called the Westinghouse Science Honors Institute.

This book is these lectures in print. Subjects include light, electrons and crystals, atomic collision and gas discharge, atomic nuclei and radioactivity, low-temperature phenomena, chemistry of solids, physics of metals, microstructure and heat treatment of metals, surface film on metals, propulsion, mathematics, arithmetic, maxima and minima in physical processes, modern analytical methods, and the interdisciplinary nature of science. If you have a budding scientist who's plaguing you with questions, give him the answers in this reference form.

Engineering Economy

WILLIAM T MORRIS. Richard D Irwin Inc, Homewood, Ill. 6 x 9, 506 pp. $10.50.

Here is detailed, analytical, and often quite mathematical approach to the problem of engineering management decisions. Emphasis is on costs, production and sales, rather than on testing and design—although many of the procedures and concepts are applicable to the latter topics.

The book covers: fundamentals of engineering decisions, managerial economics, decisions under certainty, obtaining the alternatives, sources of information, prediction and judgment, evaluating intangibles, taxes, replacement policy, a review of probability theory, decisions under risk, the recognition of risk vs assumed certainty, decisions-under-risk examples, inventory policy, bidding policy, purchasing policy, decisions under uncertainty, decisions-under-uncertainty example, game theory, statistical decisions, diversification, decisions under pressure, measurement—the unsolved problem, the economics of automation, simulated decision making, how decisions are made.

Elementary Theoretical Fluid Mechanics

KARL BRENKERT JR. John Wiley & Sons, 440 Park Ave South, New York 16. 6 x 9½, 348 pp, $7.50.

This book stresses the rigorous derivation and application of the fundamental equations (continuity, momentum, energy). Offering 374 problems, the book leans heavily on calculus and contains a minimum of empirical data and specific formulas. Yet it should prove understandable to the newcomer in the field, providing he has completed a year of calculus.

Cam and Tool Design

O T LIPPMAN. Brown & Sharpe Mfg Co, Providence 1, RI. 8 x 11, 81 pp. $7.50.

The text of this manual appeared in serialized form in Automatic Machining magazine from May '58 to December '59. The author has taught cam and tool design for almost 20 years at Brown & Sharpe.

Contents include: screw machine tooling, tooling and estimating, setup calculations, drawing cams, estimating revolutions and cam hundredths, turret tooling, layout, how to make the part-turn, form or tandem, threading, laying out threading cams, thread positions, tapping, finalizing the layout, complex part, estimate and chuck sketch.

Basic Graphical Kinematics

HAROLD B KEPLER. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 5½ x 8, 314 pp. $6.

This book stresses the graphical approach to kinematics. It keeps analytical work to a minimum and presents explanations and derivations graphically where possible. This approach enables the reader to understand the material without a knowledge of calculus. All the traditional topics of kinematics are covered.

continued on page 103

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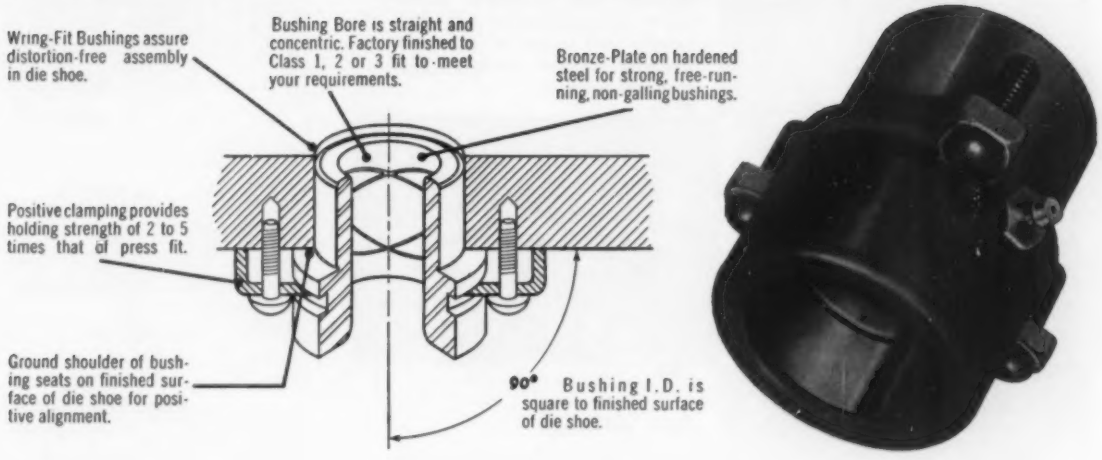
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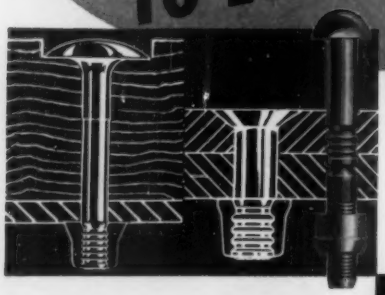

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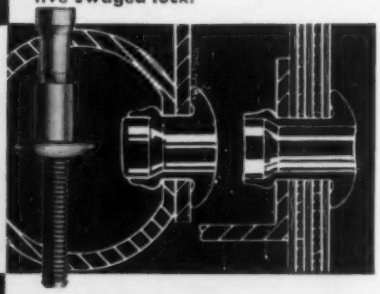

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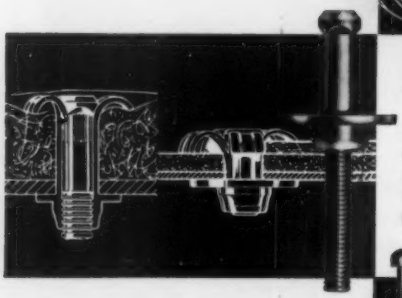

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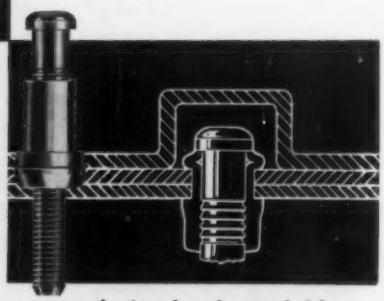

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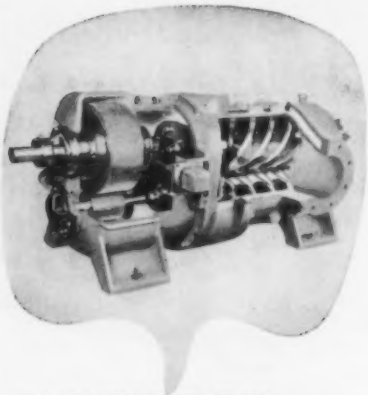

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Other Books of Interest

Picture Dictionary and Guide to Building and Construction Terms

Lipowsky and Bersten. Arco Publishing Co Inc, 480 Lexington Ave, New York 17. 8 x 10½, 57 pp. $3 paper; $5 clothbound.

Electronics Industry 1960 Fact Book

Electronic Industries Association, 1721 DeSales St, NW, Washington 6, DC. 5 x 8½, 63 pp. 75¢.

The Story of Alchemy and Early Chemistry

J M Stillman. Dover Publications Inc, 180 Varick St, New York 14. 5½ x 8, 566 pp. $2.45.

Unabridged paperback edition of early 1924 edition published under following title: "The Story of Early Chemistry".

ABSTRACTS FROM THE LITERATURE

Damped Vibrations

Vibrating bodies in normal environments are usually considered to have a sinusoidal displacement-time curve with an exponential envelope. This envelope appears to pass geometrically through the crests. This is impossible because exponential motion is only possible with zero mass. Also, for critical damping, it is often stated that the curve is approximately exponential. To explain these apparent anomalies an investigation was carried out and the results are given.

"Damped Vibrations," by W H Sheppard. Mechanical World, Sept '60, 31 King St W, Manchester, England.

Who Should Manage Engineers?

The alternatives of having engineers managed by professional managers or by other engineers are discussed. The relation of the working engineers to management is also considered.

"Who Should Manage Engineers," Glenn B Warren, General Electric Co. Mechanical Engineering, Sept '60, 29 W 39th St, New York 18.

Epoxy-resin Hardeners

A system for making fire-resistant epoxy resins is described. Anhydride curing agents can be selected to give low toxicity and excellent high-temperature characteristics. A further advantage of cost reduction can often be realized from high-molecular-

continued on page 105

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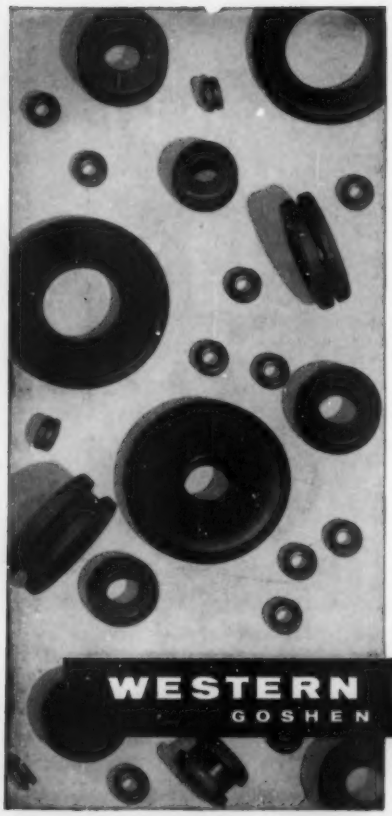

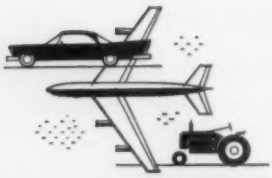

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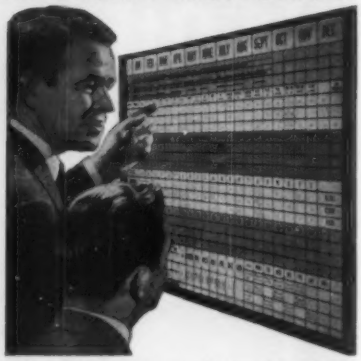

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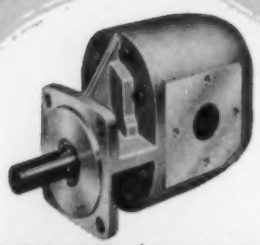

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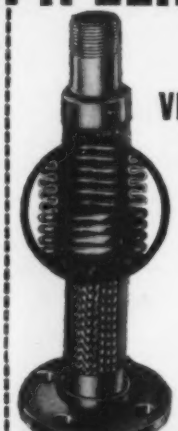

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"Hardeners for Epoxy Resins," C S Ilardo and B O Schoepfle, Hooker Chemical Corp; SPE Journal Vol 16, No. 8, August 1960, 65 Prospect St, Stamford, Conn.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 113.

PARALLEL-SHAFT SPEED REDUCERS—Brochure 2719, 36 pp. Describes redesigned and expanded line of parallel shaft reducers in 57 sizes. Contains 16 pp of rating tables and shows load classes for almost 250 driven machines. Link-Belt Co, Dept PR, Prudential Plaza, Chicago 1.

Circle 350 on Reader Service Card

FLEXIBLE SHAFTS—Handbook, 4th edition, 98 pp. Revised handbook covers advantages of flexible shafts, their function, applications, information on standard power drive and remote-control shafts, uses of accessories. Presents, for the first time, information on simplified engaging system based on integral formed square drives. SS White Industrial Div, Dept P, 10 E 40th St, New York 16.

Circle 351 on Reader Service Card

PLANNING AND PACKAGING CIRCUITRY—Catalog, 24 pp. Revised guide describes planning and packaging system for electrical, electronic equipment and gives specifications of some of the most frequently ordered components to mount, house, fasten, connect and monitor circuitry. Alden Products Co, 3167 N Main St, Brockton, Mass.

Circle 352 on Reader Service Card

THERMOPLASTIC RESINS—Booklet, 24 pp. Characteristics, applications, typical properties and fabrication information for various types of ABS thermoplastic resins. US Rubber Co, Naugatuck Chemical Div, 1230 Ave of the Americas, New York 20.

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continued on page 107

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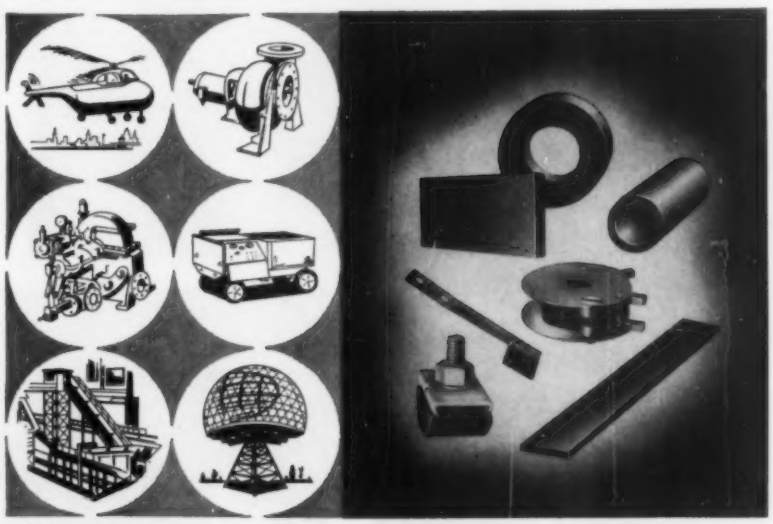

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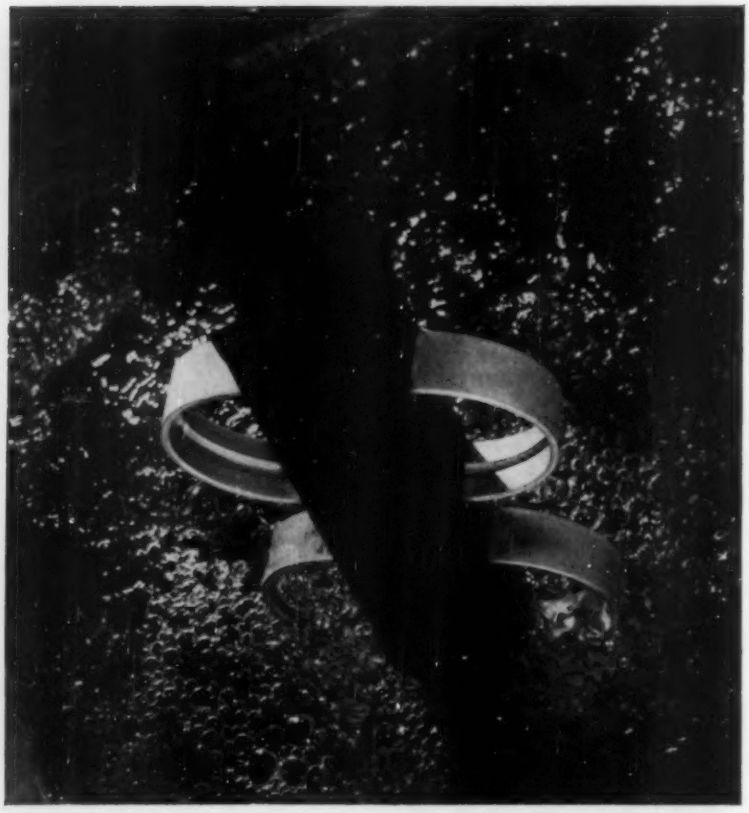

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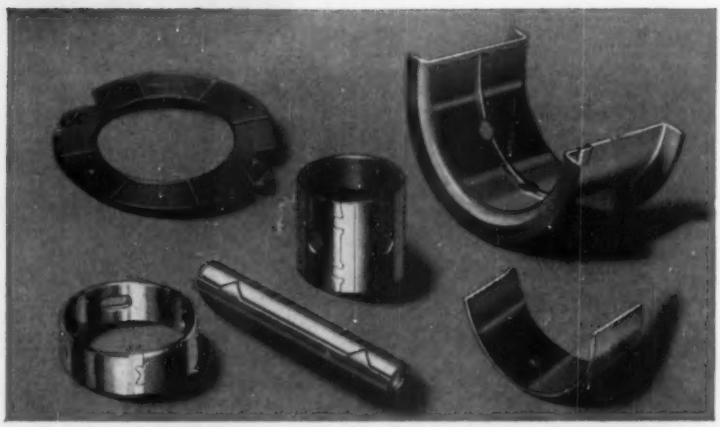

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MANUAL MOTOR STARTERS–Bulletin GEA-6358C, 12 pp. Describes manual motor starters for fhp and for integral hp motors up to 7½ hp. Photos show two basic forms for each type. Illustrations indicate construction features; outline diagrams show dimensions. General Electric Co, Schenectady 5.

Circle 354 on Reader Service Card

WELDING-ELECTRODE CHART–23 x 35 in. wall chart. Gives description, number, color code, mechanical properties, size, current range, procedure and application information for arc-welding electrodes. Also covers welding symbols, welding arc, causes and cures of common welding troubles, typical deposition rates and includes metal-hardness conversion table. Hobart Bros Co, Troy, Ohio.

Circle 355 on Reader Service Card

VOLTAGE REGULATORS – Catalog 4-265, 10 pp. Specifications of more than 2000 standard magnetic voltage-regulator models. Includes fold-out selection guide with electrical and physical characteristics of units. Raytheon Co, Power Supply and Voltage Regulator Operations, Keeler Ave, S Norwalk, Conn.

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COMPUTER CHARACTERISTICS – Chart. Lists 43 US-built, general-purpose, stored-program electronic digital computers, in sequence by decreasing rental price, together with their general characteristics, special features and specifications. Chas W Adams Associates Inc, 142 The Great Rd, Bedford, Mass.

Circle 357 on Reader Service Card

SEMICONDUCTORS–Brochure, 12 pp. Ratings and characteristics of industrial and military semiconductors. Also covers information on reliability program. Contains photos and dimensional drawings. Motorola Semiconductor Products Inc, 5005 E McDowell Rd, Phoenix, Ariz.

Circle 358 on Reader Service Card

PIPE EXTRUSION–Bulletin 15, 6 pp. Reports company recommendations for extrusion of high-density polyolefin pipe and tubing. Phillips Chemical Co, Plastics Sales Div, Bartlesville, Okla.

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MICRO-REPRODUCTION STANDARDS–Folder, 6 pp. Discusses standards and specifications of Defense Department's engineering data micro-reproduction system, based on speeches by Department spokesmen before the 1960 convention of National Microfilm Association. Minnesota Mining & Mfg Co, 900 Bush Ave, St Paul 6.

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continued on page 109

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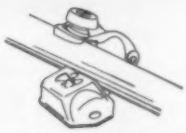

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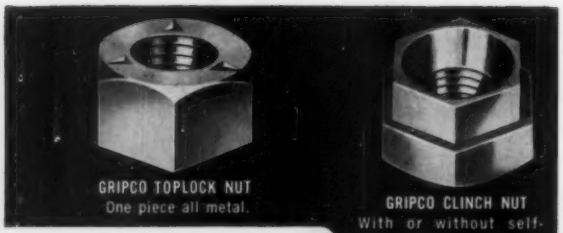

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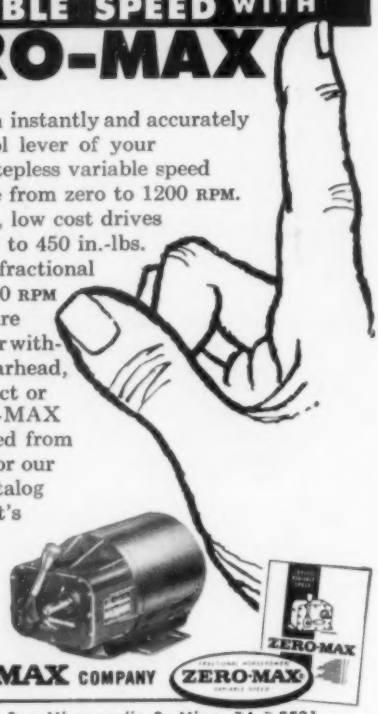

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Division of Colorado Oil and Gas Corporation
Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada
Houston Branch Plant, 1121 Anthwolf St., Sect. 15, Houston, Texas

CIRCLE 211 ON READER SERVICE CARD

HYDRAULIC EQUIPMENT – Condensed catalog EJS, 8 pp. Specifications and performance information on hydraulic components for machine tool and industrial applications. John S Barnes Corp, 315 S Madison St, Rockford, Ill.

Circle 361 on Reader Service Card

PNEUMATIC COMPUTING RELAY– Catalog 53CR1000, 8 pp. Describes operation and design features of pneumatic computing relay. Lists applications for each computer operation. Fischer & Porter Co, 547 Jacksonville Rd, Warminster, Penna.

Circle 362 on Reader Service Card

FLEXIBLE PLASTIC VACUUM HOSE –Brochure, 8 pp. Information on dimensions, construction and applications of line of flexible hose. Dayton Dayflex Plastics Co, Div of Dayco Corp, Dayton 1, Ohio.

Circle 363 on Reader Service Card

CONTROL COMPONENTS – Booklet, 8 pp. Contains illustrations and specifications of control components offered by this division. Control Components Div of International Resistance Co, 401 N Broad St, Philadelphia 8.

Circle 364 on Reader Service Card

PANEL METERS–Data sheet 601, 4 pp plus price list. Lists 92 standard models of voltmeters, ammeters, milliammeters and microammeters in 2½, 3½ and 4½ in. sizes. Data tables include meter sensitivity, standard coil resistance and standard voltage drop. Helipot Technical Information Service, Helipot Div of Beckman Instruments Inc, Fullerton, Calif.

Circle 365 on Reader Service Card

SINGLE-TURN POTENTIOMETERS– Catalog, 6 pp. Electrical and mechanical specifications for 28 standard single-turn, wire-wound potentiometers. Dimensional drawings classify line. Text describes optional mechanical features. Fairchild Controls Corp, 225 Park Ave, Hicksville, NY.

Circle 366 on Reader Service Card

GAGES, THERMOMETERS AND CONTROLS–Bulletin 3020, 6 pp. Covers dimensions, accuracies, construction, ranges and typical applications of bourdon-tube-type pressure gages, thermometers and control instruments. US Gauge, Div of American Machine and Metals Inc, Sellersville, Penna.

Circle 367 on Reader Service Card

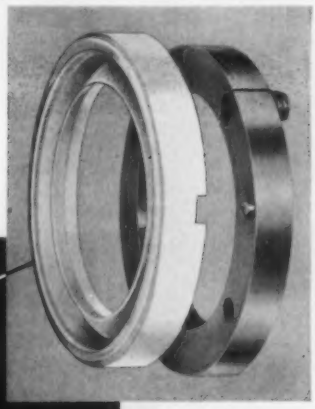
BIMETAL THERMOSTATS – Bulletin 8400, 4 pp. Revision of full-line catalog covers main types of bimetal thermostats. Gives specifications, performance data and ratings for semienclosed and hermetically sealed styles. Includes Centigrade-Fahren-

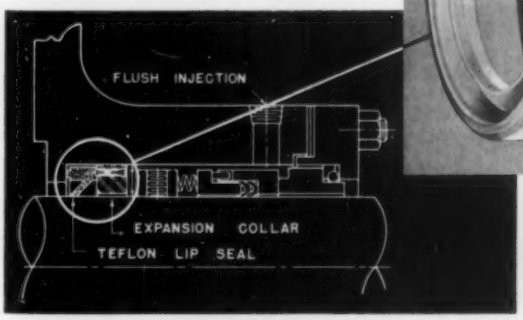
continued on page 110

DURA LIP SEAL

For use with Dura Seal to control liquid injection in stuffing boxes

FOR HANDLING ABRASIVE FLUIDS AND SLURRIES





DURA LIP SEAL

Composed of two parts: Left, Teflon lip sealing ring; Right, split expansion Collar for retaining lip sealing ring in operating position.

DURA LIP SEAL provides a flow control for liquid injection in stuffing boxes. Its purpose is to prevent abrasives in the process fluid from interfering with the function of the Dura Seal. A split Collar is expanded firmly against the stuffing box bore retaining a Teflon lip sealing ring that regulates the amount of dilution. FOR MORE INFORMATION, WRITE FOR BULLETIN NO. 491-PG

The PERFECT SEAL

DURAMETALLIC CORPORATION
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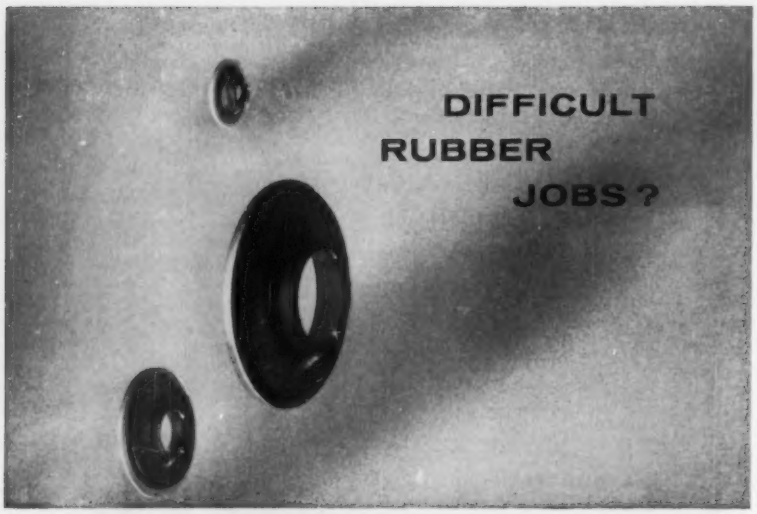

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heit temperature conversion chart. Stevens Mfg Co Inc, PO Box 1007, Mansfield, Ohio.

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PUMP MOTORS—Brochure, 4 pp. Specifications, performance information and ratings of ½ through 2 hp, single- and three-phase motors. Cutaway drawings show construction details. Franklin Electric Co Inc, 400 E Spring St, Bluffton, Ind.

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BLUEPRINT RACKS—Booklet, 6 pp. Specifications, dimensions and capacities of four racks for storage of blueprints, charts, tracings and drawings. Frontier Mfg Co, 11200 Harry Hines Blvd, Dallas.

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METAL-FINISHING PRODUCTS, PROCESSES—Bulletin PP-103, 4 pp. Lists metal-finishing products produced by company and describes 19 available metal-finishing processes. Hanson-Van Winkle-Munning Co, Church St, Mattawan, NJ.

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DRAWING INSTRUMENTS AND CASES—Catalog 60-IC, 6 pp. Contains information on combinations of drawing instruments and cases available. V & E Mfg Co, 766 S Fair Oaks Ave, Pasadena, Calif.

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REDUCING AND RELIEF VALVE—Catalog sheet, 2 pp. Describes features, capacity, operation, applications and specifications of valve for water, oil, air or gas service to initial pressures of 4000 psi. Atlas Valve Co, 280 South St, Newark 5, NJ.

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SPECIAL-PURPOSE COAXIAL CABLE—Data sheet, 2 pp. Tabulates impedance, capacitance, construction details and general applications of special-purpose cables, grouped in six temperature ranges from 176 to 482 F. Times Wire and Cable Div, International Silver Co, Wallingford, Conn.

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GENERATORS AND MOTOR GENERATORS—Bulletin 700 (A, B), 2 pp. Characteristics, ratings and applications of ½ to 15 kva, ac, and ½ to 3 kw, dc generators. Howell Electric Motors Co, 16316 W 7 Mile Rd, Detroit 35.

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TEMPERATURE MEASUREMENT—Booklet, 4 pp. Presents descriptions, temperature ranges, prices of three portable, temperature-measuring devices for use

continued on page 113

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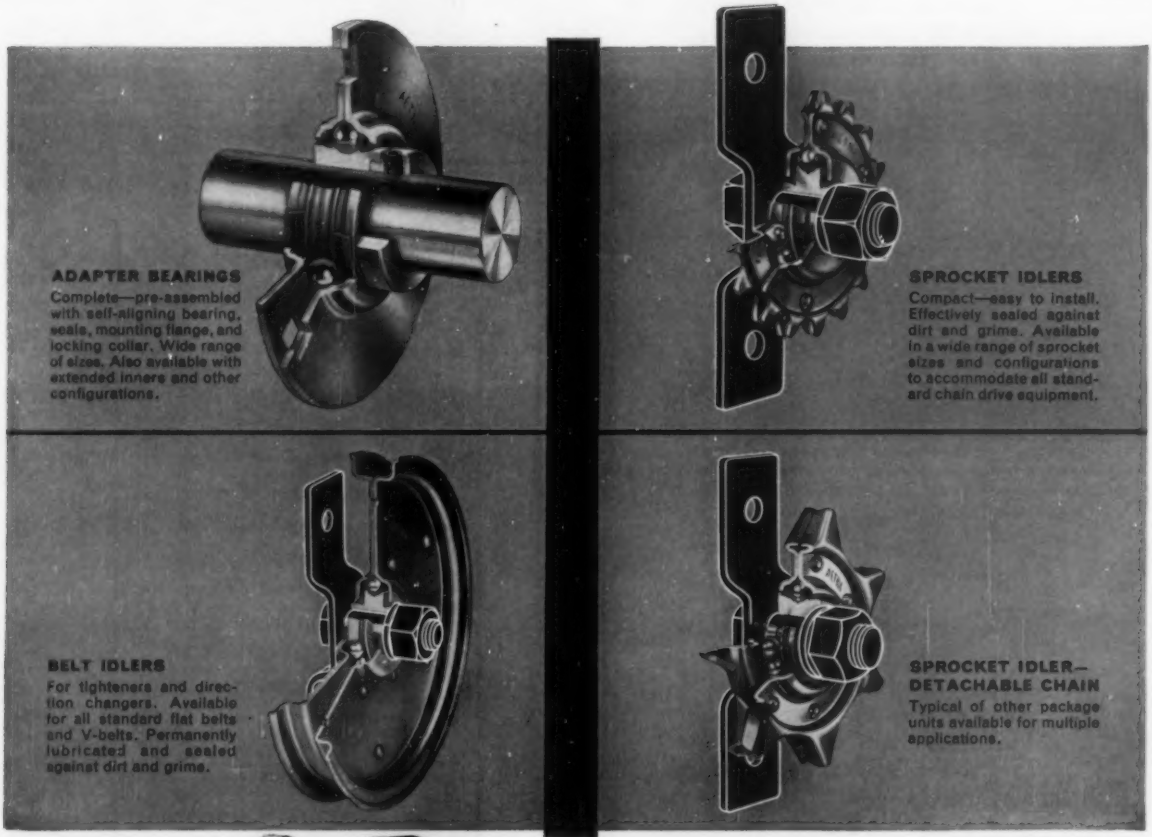

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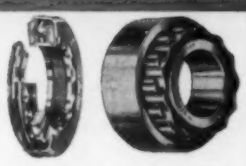

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Circle 376 on Reader Service Card

KNURLED AND SERRATED INSERTS—Data sheet 200-59, 1 p. Sizes, materials and characteristics of knurled and serrated inserts for pressing into cold material, hot materials or for molding applications. J B Plevyak Mfg Co, 19 Jefferson St, Newton, NJ.

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Manufacturers who published following literature asked that requests for copies be made on company letterheads.

THREADED COAXIAL CONNECTORS—Catalog, 32 pp. Specifications and dimensions of standard and special RF connectors for precision equipment. With dimensional drawings. General RF Fittings Inc, 702 Beacon St, Boston 15.

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continued on page 115

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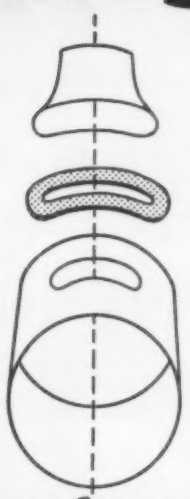

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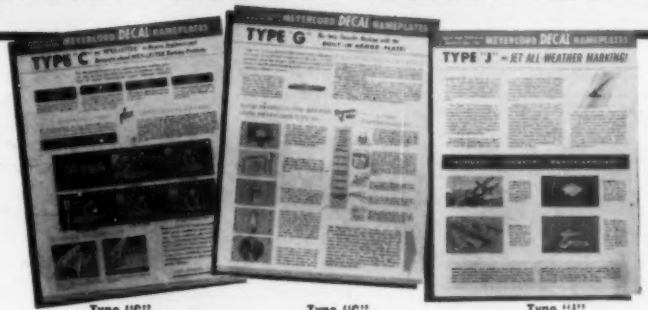

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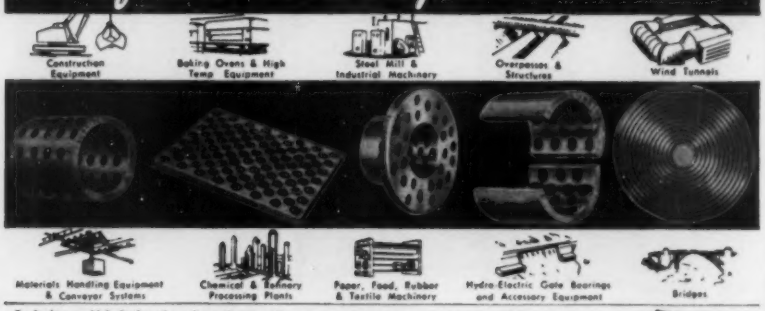
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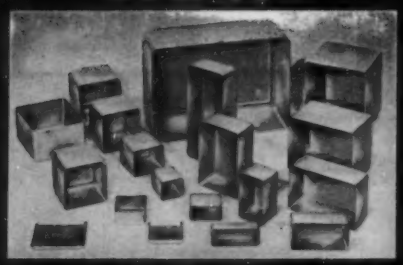

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GENERAL ELECTRIC

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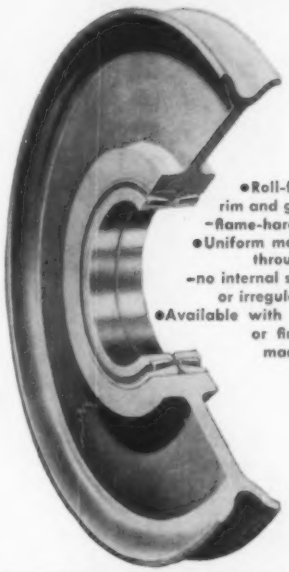

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CLASSIFIED ADVERTISING
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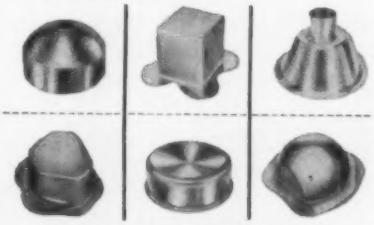

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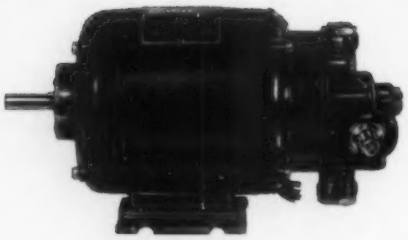

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. . . Ernest A. Massa, vice president
Massa, A division of
Cohu Electronics

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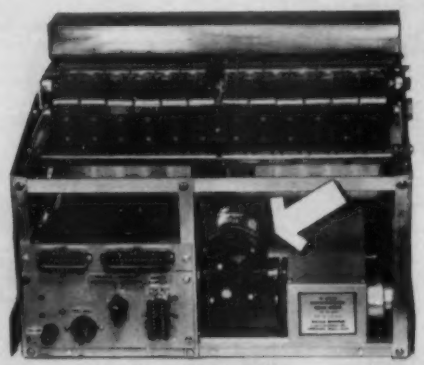

Rear interior view

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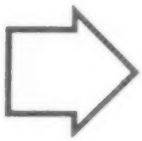

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New equations give life expectancy for gears, cams, bearings.

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Dimensional analysis of all units needed in control service.

P52—SELECTING SOLENOIDS

A guide to ac or dc, and linear or rotary types.

P53—LIGHT-DUTY BELT DRIVES

Performance compared for all five basic types.

P54—EPICYCLIC GEAR SYSTEMS

Modified equations give volume, power capacity, speed ratios, stresses.

P56—TAPERED CANTILEVER BEAMS

How to calculate stresses and deflections for five sections.

P57—MOLDED PLASTIC CAMS

When they are preferable to steel cams individually machined.

P58—STRONG ALUMINUM ALLOYS

How the new X2020 stacks up with other high-strength alloys.

P59—THE RESPONSE EQUATION

Some graphical tricks that eliminate tedious slide rule work.

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Evaluation of all types suitable for control applications.

P61—DIMENSIONAL STABILITY IN PRECISE PARTS

How properties change under stress and heat.

P62—FRICTION COEFFICIENTS

Complete table; how to adapt values to actual service.

P63—QUICK-CONNECT COUPLINGS

For hydraulic and pneumatic systems; basic types and variations.

P64—BENDING GAGE

New strain gage system measures from one side of section.

P65—HELICAL GEARS

How to change pitch diameter by varying pitch angle.

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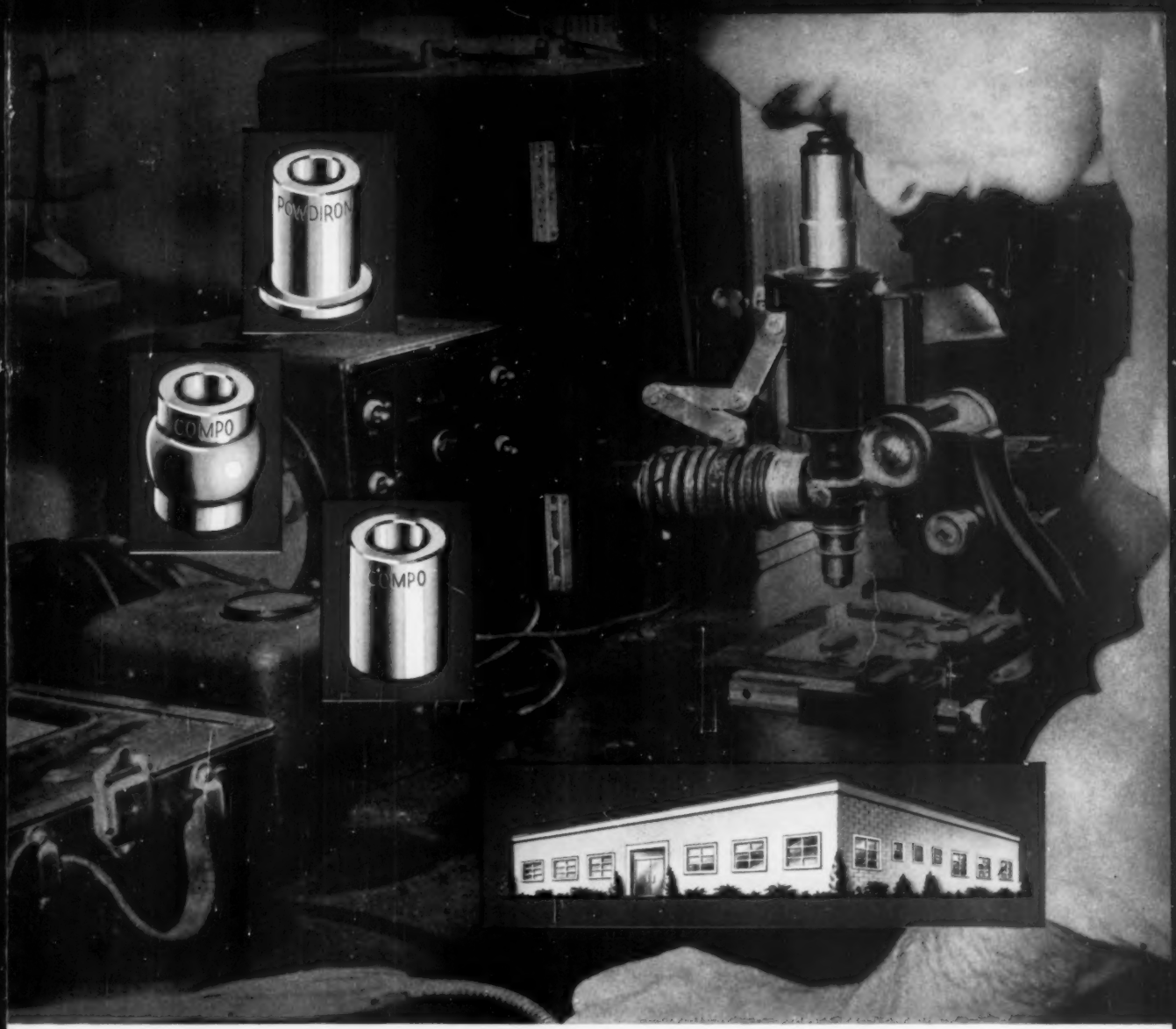

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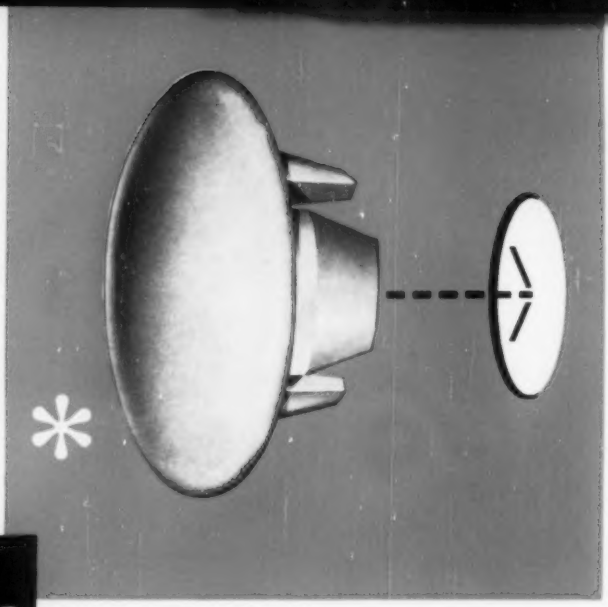

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